UFSCar
N.º: 033/2025
Processo: 23112.024757/2024-11

COOPERATION AGREEMENT

The following companies and institutions

CEMEA (Centre for Advanced Materials Application) | Dúbravská cesta 5807/9, 845 11 Bratislava, Slovakia

UFSCar (Federal University of São Carlos) | 235km Washington Luís Highway, 13565-905 São Carlos, State of São Paulo, Brazil

TUD Dresden University of Technology | Helmholtzstraße 10, 01069 Dresden, Germany, represented by the Chancellor

Acting site: Institute of Materials Science, Chair of Inorganic Non-Metallic Materials

And

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. | Hansastraße 27c, 80686 Munich

for services of its

Fraunhofer-Institute for Ceramic Technologies and Systems IKTS | Winterbergstraße 28, 01277 Dresden, Germany

hereinafter referred to as the “Partners”

hereby enter into the following agreement on the collaborative implementation of the

“Ceramic Anode Host Material for Confined Sodium Plating (Na-CerAnode)”

joint project:

Within the framework of the "M-ERA.NET" Program, each Partner has applied for governmental funding for its participation in the Joint Project from its respective national funding authority in the country where it is located.

Subject to each Partner's obtaining of the necessary grant from its respective national funding authority, the Partners agree on the terms and conditions below.

1
Subject matter of the Agreement
Subject of this Agreement are the terms of the collaboration on the

"Ceramic Anode Host Material for Confined Sodium Plating (Na-CerAnode)"

joint project (hereinafter referred to as the "Joint Project").

The tasks to be performed by each Partner are specified in their respective funding grant. Each Partner is solely responsible for the performance of its own tasks and the underlying request for allocation of funds (including the work plan) as listed in detail in the "Full Project Proposal" attached as **Annex A** to this Agreement. This Annex A shall form an integral part of this Agreement. In the event of any inconsistencies, this Agreement shall prevail over its Annex(es).

Each Partner shall bear its own costs relating to the Joint Project.

2
Term
The Joint Project shall commence on the earliest date stipulated in one of the funding notifications obtained from the respective governmental funding authority. For those Partners, who have a later date in their respective funding notification the Joint Project shall commence on that date, stipulated in their respective funding notification. The Joint Project shall continue in effect until completion or until the Partners otherwise agree to terminate it. The target date for the completion of the Joint Project is June 30th, 2027.

3
Coordination
3.1
The Joint Project shall be coordinated by **Fraunhofer IKTS** (hereinafter referred to as the "Coordinator"). The Coordinator shall be the intermediary between the Partners and the respective European Office e.g. the M-ERA.NET Call Secretariat and shall perform all tasks assigned to it as described in the provisions of its national funding authority and in this Agreement.

3.2
For the purposes of implementation of the Joint Project, each Partner shall name a contact person. The Partners shall direct their notices and declarations to the attention of the contact persons.

3.3
The Coordinator shall be responsible for the following:

- monitoring compliance by the Partners with the time schedule of work plan.
- keeping the address list of the Partners' contact persons updated and available.
- collecting, reviewing and submitting information on the progress of the Joint Project, reports and other deliverables.
- preparing meetings of the Partners, chairing the meetings, preparing the minutes of the meetings and monitoring the implementation of decisions taken at the meetings or by written consent of all the Partners in lieu of a meeting.
- transmitting documents and information connected with the Joint Project to the Partners.

3.4
Each Partner will provide the Coordinator with the Joint Project documents needed by the Coordinator to perform his/her tasks as Coordinator, particularly in order to forward them to the respective European Office e.g. the M-ERA-NET Call Office. Each Partner is responsible to provide its documents/reports to its national funding authority.

3.5
No Partner including the Coordinator shall be authorized to deliver binding legal declarations, enter into legally binding agreements or accept payments on behalf of any other Partner, without prior written consent of that Partner.

3.6
The Coordinator shall convene ordinary meetings at least once every six months and shall also convene extraordinary meetings at any time upon written request of any Partner. The Coordinator shall provide written notice of a meeting – including an agenda – to each Partner as soon as possible and in any case at least 14 calendar days preceding an ordinary meeting and at least seven calendar days preceding an extraordinary meeting. Meetings may be held at a location acceptable to all of the Partners; they may also be held by teleconference or other telecommunication means provided that each of the Partners is able to hear and be heard at the meeting. The Coordinator shall produce written minutes of each meeting which, after written approval by each Partner, shall be the formal record of all decisions taken with regard to the Joint Project.

4
Work results/Rights of use
4.1
In regard to the subject of this Agreement, the Partners shall inform each other of their respective inventions and the industrial property rights applied for or granted thereto, know-how or copyright-protected works, including software, achieved in the course of implementing the Joint Project (hereinafter collectively referred to as “Work Results”) and about the progress of work, and the Partners shall exchange interim and final reports.

4.2
The Partners shall grant each other a non-exclusive, non-transferable right of use at no charge for Work Results achieved solely by the respective Partner for the duration and implementation of the Joint Project.

For any further usage, each Partner shall be granted upon request, which must be asserted in writing to the respective Partner within one year after the end of the Joint Project, a non-exclusive, non-transferable right of use at standard market rates and at terms and conditions to be agreed upon prior to any intended use, which shall be established in a specific agreement or contract.

When assessing the standard market terms, the necessary contributions made by the concerned Partners in the context of the Joint Project for the respective Work Result shall be taken into account; compared to the terms for uninvolved parties, the relevant Partner may be given a corresponding discount for such contributions.

Insofar as no request for further use was asserted within the one year period or, following a timely request, no agreement was able to be reached about the terms and conditions of use, except with respect to the Work Results jointly achieved, then each Partner shall be free in the commercial exploitation of its Work Results achieved independently.

Work Results in form of Software independently developed by any Partner in the duration and implementation of the Joint Project shall be provided in object code only.

4.3
The joint inventions, which result from implementation of the Joint Project (i.e. inventions in which employees of several Partners are involved and for which the individual Partners cannot file separate industrial property rights applications for their share of the invention), shall be owned jointly by these Partners in proportion to their share of the invention.

The Partners involved in joint inventions shall agree upon the registration (including management thereof), maintenance and defense of industrial property rights to the joint invention, as well as the associated costs. These Partners shall be entitled to use such inventions as well as industrial property rights applied for or granted thereto for the term thereof like their own and to grant non-exclusive licenses thereto upon fair and reasonable compensation. Only the Joint Owners will be entitled to use such inventions without any financial compensation for noncommercial, internal research and teaching purposes without collaboration with third parties or other Partners.

The rights of the other Partners shall be determined according to Section 4.2.

For copyright protected Work Results which are jointly created during the implementation of the Joint Project by employees of several Partners (including software) as well as jointly created know-how, the provisions of this Section 4.3 – to the extent to which they may be applicable – shall apply accordingly.

4.4

The Partners shall grant one another, upon written request, a non-exclusive, non-transferable, non-sublicensable right of use at no charge to inventions and the industrial property rights applied for or granted thereto, know-how and copyright-protected works, including software, existing at the time of commencement of this Agreement which were incorporated by them into the Joint Project (hereinafter collectively referred to as "Background IP"), for the duration and implementation of the Joint Project, provided the Partners are legally able to do so and to the extent this is necessary for the implementation of the Joint Project.

For any further usage, to the extent that it is imperative for the exploitation of a Partner's own Work Results, the other Partners shall, upon request, which must be submitted in writing to the respective Partner within one year after the end of the Joint Project, grant this Partner a non-exclusive, non-transferable, non-sublicensable right of use for a fee at standard market terms, provided they are legally able to do so. The details of this arrangement shall be agreed upon in writing by the relevant Partners prior to commencing any such further usage of the Background IP.

Work Results in form of Software independently developed by any Partner in the duration and implementation of the Joint Project shall be provided in object code only.

4.5

The rights of use granted pursuant to this Agreement shall only include those acts of use which do not constitute acts detrimental to qualification as a novelty.

Neither the granting of rights of use pursuant to this Agreement nor the exercise thereof should establish any right based on prior use. In this respect, no Partner shall invoke a right based on prior use.

4.6

If any work to be performed by a Partner is performed by a third party, then this Partner shall ensure that the Work Results achieved thereby shall be provided to the other Partners and rights of use are granted thereto pursuant to the terms of this Agreement.

5

Confidentiality

5.1

Each Partner shall use all information of the other Partners that is classified as confidential exclusively for the Joint Project, shall keep it confidential and shall not provide it to third parties without the prior written consent of the relevant Partner during the Joint Project and for a period of five (5) years after the end of the Joint Project. This obligation shall not apply if and insofar as the information

- was known to the public or was generally available prior to the notification to the receiving Partner or
- becomes known to the public or generally available after the notification to the receiving Partner without that Partner being involved or at fault or
- the receiving Partner was already aware of at the time of receipt of the information or
- matches information that was disclosed or made available to the receiving Partner at any time by a third party, unless the receiving Partner knew that the third party's disclosure breaches a duty of confidentiality, or

– was developed by an employee of the receiving Partner without knowledge of the information.

If a government authority or a court orders the disclosure of Confidential Information, then the Receiving Party will be authorized to make a disclosure insofar as the order demands such disclosure, provided that the Receiving Party to the extent allowed by law informs the Disclosing Party without undue delay about any such order for purposes of protecting its rights and provided that the Receiving Party limits the disclosure to the requisite minimum and informs about the confidentiality of the Confidential Information at the time of the disclosure. Section 5 remains otherwise unaffected thereby.

5.2
The internal dissemination of confidential information by a Partner shall be permitted only insofar as this is necessary for the Joint Project (on a need-to-know basis) and provided it can be ensured that the only employees who receive this information are employees who have been made subject, to the extent legally possible, to the same confidentiality requirements.

5.3
The receiving Partner further agrees not to reverse engineer the confidential information of the disclosing Partner without the prior written consent of the disclosing Partner, unless reverse engineering is legally allowed.

6
Publications
6.1
Each Partner is entitled to issue publications that do not contain any confidential information or Work Results of other Partners without the consent of the other Partners.

6.2
Publications containing confidential information and/or Work Results of another Partner shall require prior written consent of that Partner (email is sufficient) and must be submitted to that Partner prior to the publication. With respect to joint Work Results, consent may not be unreasonably withheld or delayed.

6.3
Any disclosure or notification obligations by the Partners to a Funding Authority shall remain unaffected.

6.4
The Partners must ensure that all Joint Project publications, etc. include a proper acknowledgement to M-ERA.NET, the European Commission, and the respective Funding Authority/Organization.

7
Liability/Warranty
7.1
No Partner shall warrant or be liable for the correctness, completeness, fitness for a particular purpose, merchantability, exploitability, freedom from defects or freedom from third party industrial property rights of Work Results, Background IP and other information transferred in the context of this Agreement. The foregoing limitations of liability shall not apply in cases involving intentional acts or omissions.

7.2
Claims of the Partners against one another, against their managing employees and legal representatives, vicarious agents and assistants for compensation of damages based on breaches of duty and tortious acts are excluded, provided they are not based on intentional acts or omissions or on gross negligence. Liability for indirect damage and consequential damages is excluded, unless such damages were caused by intentional acts or omissions. Section 7.1 shall remain unaffected.

7.3
For third party claims, the Partners shall be liable among themselves (inter se) in accordance with their share of fault.

8
Notice of termination/Termination

8.1
Each Partner may terminate its involvement in the Joint Project upon three (3) months' notice, but only for good cause. Good cause shall exist particularly if continued work has become unreasonable or the Partner's grant is subsequently reduced significantly or revoked. The notice of termination must be sent to all Partners and to the respective Funding Authority in writing and along with return receipt. The terminating Partner shall withdraw from the Joint Project when the termination takes effect.

8.2
If court orders are issued against the assets of a Partner in connection with any instituted insolvency proceedings, then this Partner shall withdraw from the Joint Project at that time, without requiring any notice of termination. The same shall apply if any Partner has applied for insolvency proceedings or comparable legal proceedings with regard to its own assets, but such proceedings were not instituted due to lack of assets. As soon as a Partner becomes aware of any application for any of the proceedings specified in the foregoing two sentences, that Partner is obligated to inform the other Partners thereof without undue delay.

8.3
In the event of the withdrawal of a Partner pursuant to Section 8.1 or 8.2

- this Agreement between the other Partners shall remain in effect and these Partners shall continue the Joint Project subject to the provision of Section 8.4;
- the rights granted to the withdrawing Partner pursuant to Section 4 shall terminate, with the exception of its rights pursuant to Section 4.3;
- the withdrawing Partner shall remain subject to the obligation of confidentiality pursuant to Section 5;
- Section 6 shall continue to apply;
- the rights of use granted to the other Partners through this Agreement shall remain unaffected;
- the duties of the withdrawing Partner may be fulfilled by one of the remaining Partners or a new partner in consultation with the remaining Partners and the respective Funding Authorities and the respective European Authorities.

The duties of the other Partners pursuant to Section 4 of this Agreement shall apply with respect to the withdrawing Partner only for Work Results which were achieved prior to the effective date of the termination.

8.4
If the remaining Partners mutually determine that the aim pursued by the Joint Project cannot be achieved and thus the basis for this Agreement no longer applies, then the remaining Partners shall agree with the respective Funding Authorities and the respective European Authorities on future steps and, if necessary, shall enter into a separate agreement in that regard.

9
Miscellaneous

9.1
This Agreement and the document attached hereto as Annex A constitute the entire Agreement and understanding between and among the Partners with respect to the subject matters of the Joint Project, and supersede and replace any prior agreements and understandings, whether oral or written, between or among them with respect to such matters.

For the signature of this Agreement electronic signatures according to § 127 III BGB (e.g. via an electronic signature platform like DocuSign or AdobeSign or) shall be sufficient for the Agreement's legal validity. There shall neither be an exchange of handwritten original signatures nor a subsequent qualified electronic signature or certification according to § 127 II, III BGB in the case of electronic signature. This provision applies also for changes or additions to this Agreement as well as if the Partners intend to waive the agreed form.

9.2
This Agreement is subject to the funding of all Partners by the Funding Authorities. In case this Agreement is in conflict with the respective national funding regulations applicable to a Partner, the terms of the latter shall prevail with regard to that Partner. If such national funding regulations jeopardize the rights of the other Partners stipulated in this Agreement, the Partner has to notify the other Partners thereof without undue delay. Any other claims resulting from this conflict shall be excluded.

9.3
Should any provision of this Agreement be or become invalid or unenforceable under applicable law, this shall not affect the validity and enforceability of the rest of this Agreement. The Partners are obligated to replace the invalid and unenforceable provision with a valid and enforceable one that reflects the sense and purpose of the invalid and unenforceable provision. The same shall apply accordingly in the event of any unintentional gap in the provisions.

9.4
This Agreement is governed by the laws of the Federal Republic of Germany without reference to its conflict of law provisions. The United Nations Convention on the International Sale of Goods shall not apply to transactions taking place pursuant to this Agreement.

9.5
If any controversy or claim shall arise under, out of or relating to this Agreement, the Partners shall attempt to settle such dispute in good faith involving at least one senior representative of each Partner. Each Partner is entitled to terminate the negotiations at any time and to have recourse to a proceeding set forth in the following through written notification to the other Party.

Any dispute, controversy or claim arising under, out of or relating to this Agreement and any subsequent amendments of this Agreement, including, without limitation, its formation, validity, binding effect, interpretation, performance, breach or termination, as well as non-contractual claims, shall be submitted to mediation in accordance with the WIPO Mediation Rules. The place of mediation shall be the place of the defendant, unless otherwise agreed upon. The language to be used in the mediation shall be English unless otherwise agreed upon.

If, and to the extent that, any such dispute, controversy or claim has not been settled pursuant to the mediation within 60 calendar days of the commencement of the mediation, such dispute shall thereafter be submitted to the International Court of Arbitration of the International Chamber of Commerce and shall be settled under WIPO Arbitration Rules by 3 (three) arbitrators appointed in accordance with said rules of arbitration. The arbitral award shall be final and binding on the Parties. However, nothing in this Clause shall prevent a Party from applying to any appropriate court for any interim legal protection to restrain the other Party from committing any breach or anticipated breach of this Agreement.

The place of arbitration shall be the place of the defendant, unless otherwise agreed upon. The language to be used in the arbitral proceedings shall be English.

9.6
Each Partner shall comply with the applicable export law provisions.

9.7
No Partner may transfer this Agreement or individual rights or obligations under this Agreement to third parties without the written consent of the other Partners. This shall not apply to the extent that a Partner merely assigns partial performances of the Joint Project to a third party under a subcontract provided that such assignment shall not relieve the Partner from its own liability hereunder. In any such case, the assigning Partner, as a condition precedent to such assignment to a subcontractor, shall obtain valid and binding contractual assurances from its subcontractor to comply with all obligations, including without limitation with respect to confidentiality, under or arising in connection with this Agreement and that the results obtained by the subcontractor will be made available to the other Partners in accordance with Section 4 above.

9.8
The headings used herein and in any of the documents attached hereto as exhibits are descriptive only and for the convenience of identifying provisions, and are not determinative of the meaning or effect of any such provisions.

9.9
The failure of any Partner at any time to require performance by the other Partner or Partners of any provision hereof shall not affect in any way the right to require such performance at any time thereafter, nor shall the waiver by any Partner of a breach of any provision hereof be taken or held to be a waiver of any subsequent breach of the same provision or any other provisions.

9.10
Nothing contained in this Agreement shall be deemed to constitute a joint venture, agency, partnership, interest grouping or any other kind of formal business grouping or entity between or among the Partners. No Partner shall have the right or authority to assume or create obligations or responsibilities, express or implied, on behalf of or in the name of another Partner, or to bind another Partner in any manner without the prior written consent of the other Partner or Partners.

10
Effective date
This Agreement shall take effect upon its execution.

11
Languages
This Agreement is drawn up in English and Portuguese. In the event of any differences, discrepancies or controversies between the version hereof in English language and the version hereof to Portuguese language, the version of this Agreement in English language shall prevail.

Annexes
Annex A: Full Project Proposal

-- Signature pages follow --

Bratislava, Apr 1, 2025

CEMEA (Centre for Advanced Materials Application)

doc. Ing. Miroslav Hnatko

Miroslav Hnatko
Miroslav Hnatko (Apr 1, 2025 08:21 GMT+2)

Signature

Dr. Peter Siffalovic

Peter Siffalovic
Peter Siffalovic (Mar 31, 2025 22:22 GMT+2)

Signature

São Carlos, -- *date of Prof. Ana Beatriz de Oliveira's signature* --

UFSCar (Federal University of São Carlos)

Prof. Ana Beatriz de Oliveira

gov.br Documento assinado digitalmente
ANA BEATRIZ DE OLIVEIRA
Data: 25/03/2025 17:01:08-0300
Verifique em https://validar.iti.gov.br

Signature

Prof. Ana Candida Martins Rodrigues

gov.br Documento assinado digitalmente
ANA CANDIDA MARTINS RODRIGUES
Data: 25/03/2025 10:46:59-0300
Verifique em https://validar.iti.gov.br

Signature

Dresden, Mar 28, 2025

TUD Dresden University of Technology

Dr. Friederieke Noack

i.A. F. Noack
Friederieke Noack (Mar 28, 2025 13:14 GMT+1)

Signature

Dr. Stefan Schuldt

S.Schuldt
S.Schuldt (Mar 31, 2025 10:40 GMT+2)

Signature

München, Mar 27, 2025

Fraunhofer-Gesellschaft e.V.

Dr. Patrick Prestel

Patrick Prestel
Patrick Prestel (Mar 27, 2025 16:23 GMT+1)

Signature

Dr. Marianne Bösl

Marianne Bösl
Marianne Bösl (Mar 27, 2025 16:27 GMT+1)

Signature

Annex A

Full Project Proposal

-- Full Project Proposal pages follow --

[Na-CERANODE] Consortium agreement in English

Final Audit Report 2025-04-01

Created:	2025-03-27
By:	Marcelo Fila Pecenin (convenios-srinter@ufscar.br)
Status:	Signed
Transaction ID:	CBJCHBCAABAAXaVyAv8V9A2TvP_QBJZWe7yyjxjB59PT

"[Na-CERANODE] Consortium agreement in English" History

Document digitally presigned by ANA CANDIDA MARTINS RODRIGUES (acmr@ufscar.br)
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Document digitally presigned by ANA BEATRIZ DE OLIVEIRA (biaoliveira@gmail.com)
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Document created by Marcelo Fila Pecenin (convenios-srinter@ufscar.br)
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2025-03-27 - 11:24:51 AM GMT

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2025-03-27 - 2:31:12 PM GMT

Signer patrick.prestel@zv.fraunhofer.de entered name at signing as Patrick Prestel
2025-03-27 - 3:23:29 PM GMT

Document e-signed by Patrick Prestel (patrick.prestel@zv.fraunhofer.de)
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Document emailed to friederieke.noack@tu-dresden.de for signature
2025-03-27 - 3:27:50 PM GMT

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2025-03-28 - 12:14:00 PM GMT

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2025-03-28 - 12:14:47 PM GMT

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2025-03-28 - 12:14:51 PM GMT

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2025-03-31 - 8:39:57 AM GMT

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2025-03-31 - 8:40:49 AM GMT

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2025-03-31 - 10:32:09 AM GMT

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Document emailed to miroslav.hnatko@savba.sk for signature
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2025-04-01 - 6:21:55 AM GMT

Document e-signed by Miroslav Hnatko (miroslav.hnatko@savba.sk)

Signature Date: 2025-04-01 - 6:21:57 AM GMT - Time Source: server

Agreement completed.

2025-04-01 - 6:21:57 AM GMT

M-ERA.NET Full-Proposal Summary

Project overview

Project reference number	project11401
Acronym	Na-CerAnode
Full title	Ceramic Anode Host Material for Confined Sodium Plating
Keywords	advanced battery design, sodium ion batteries, ionic conductor, functional interfaces, ceramic materials, Sodium metal battery
Call topic	Sustainable advanced materials for energy
Total project costs	873.742 EUR
Requested funding	853.742 EUR
Total person months	101
Planned project start	07/2024
Project duration (in month)	36
Technology Readiness Level	project start: 1 project end: 4
Uploaded Full-Proposal	Na-CerAnode_Full-proposal final.pdf
Uploaded Full-Proposal Annex	Na-CerAnode_annex1_toFullProposalform final.pdf
Project partners agreement	The coordinator confirms that all project partners have agreed to the content and the submission of this proposal.
Data privacy policy	The coordinator confirms that all project partners have read and accepted the M-ERA.NET data privacy policy.
Consent mailing list	You agree that your email will be added to the M-ERA.NET mailing list.
Submission state	The proposal has submitted. Last submission time: 2023-11-21 10:13:58
Printing date	2023-11-21 10:14:07

Project partner overview

Type	Organisation	Total costs	Requested funding	Funding organisation
Coordinator	Fraunhofer Institute for Ceramic Technology and Systems IKTS	455.342 EUR	455.342 EUR	SMWK
Partner 2	Centre for advanced materials application SAS (CEMEA)	140.000 EUR	120.000 EUR	SAS
Partner 3	Universidade Federal de São Carlos (UFSCar)	83.400 EUR	83.400 EUR	FAPESP
Partner 4	Technische Unversitaet Dresden	195.000 EUR	195.000 EUR	SMWK

Project summary

Generation 5 Sodium-based batteries (SIB) are an emerging technology. They are safe, cost-effective, and rely on abundant elements and are thus an alternative to lithium-ion batteries (LIB). However, their limited gravimetric but in particular volumetric energy density hinders them to become a lead technology for mobile energy storage. Efforts are still needed to improve energy and power density, fast-charging capability, and lifetime, as well as to reduce manufacturing costs and enable full recyclability. The project Ceramic Anode Host Material for Confined Sodium Plating – Na-CerAnode solves these issues by developing a porous substrate for sodium metal storage as a physical host anode. The design concept enables anodes with negligible volume change during cycling, high specific capacity of 1000 mAh g-1 and high safety. The project furthermore develops advanced FLASH-sintering technology to reach high ionic conductivities on component level of at least 0.5 mS cm-1 at a reduced energy and time demand. Interfacial surface design by ALD-coating enables fast charging at 5 C and a high sodium cycling efficiency for application as a zero excess ("anode free") sodium metal battery (SMB). The project is further aided by advanced operando characterization to clarify sodium nucleation and stripping/plating processes. To reach these targets, the project will develop and adapt tape-casting technology to sinter porous sodium-ion conductor substrates (TRL 2 -> TRL 4), FLASH-sintering technology (TRL 1-2 -> TRL 3), ALD coating of porous inner surfaces (TRL 2 -> TRL 4) and demonstrate a full cell based on the physical anode concept (TRL 1 -> TRL 3). It will furthermore address a circular economy (such as repair, remanufacturing, recycling) for batteries with the new anode material, derive a recycling concept based on LIB recycling, and provide a first techno-ecological analysis (TEA). The project is thus in line with sustainability, and RRI requirements and will support open science.
Na-CerAnode will provide support for the whole innovation chain. After validation of the Na-CerAnode concept at TRL 3-4, the economic risk associated with further development can be shouldered by companies i.e., the obtained knowledge can be transferred to subsequent joint research projects between academia and industry empowering European companies in the market of battery production. The project will support the European Green Deal by increasing attention to clean energy technologies and future batteries by proposing a next-generation battery principle, which avoids the use of rare and conflictive resources, such as lithium. The project also supports the achievement of Sustainable Development Goals, in particular SDG 7 ("Affordable and clean energy") by focusing on an energy storage technology, that is both affordable by using abundant raw materials and clean through energy savings during production, by increasing long term stability , and simplifying recycling strategies. This also contributes to socio-ecological benefits in the context of Responsible Research and Innovation (RRI), since the establishment of a sustainable energy storage infrastructure is of socio-ecological, ethical and political dimensions.
Na-CerAnode finally strengthens the international cooperation and thus joins the technological and scientific potential of three participating countries / regions (Germany / Saxony, Slavakia and Brazil / Sao Paulo) to increase the competitiveness of European and South Americas science and economy.

Publishable Abstract

Needs to be addressed
New battery technologies are needed that can be efficiently manufactured from abundant or recycled materials, have a long life, meet the performance requirements of the application and are designed to be viable and effectively recyclable. These technologies are essential to support global growth in the renewable energy sector.
Objectives
To develop processes for a novel anode for sodium-ion batteries using a porous solid separator. Improve the performance of the anode by depositing ALD layers within the porosity and applying advanced characterization technologies. Proof of feasibility in a demonstration cell.
Potential applications
Sodium-ion batteries for stationary energy storage, and small cost-effective electric vehicles.
Impact and potential benefits
Improve ecological impact of sodium-ion batteries by applying the new anode concept. Developed novel processes for next-gen batteries are of interest for engineering industry or battery cell manufacturers.

Coordinator	
PIC	999984059
Legal name	FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV
NACE code	
Organisation	Fraunhofer Institute for Ceramic Technology and Systems IKTS
Organisation type	Research org.
Department	Mobile Energy Strorage and Electrochemistry
Street	Winterbergstr. 28
City	Dresden
Postal code	01277
Country	Germany
Website	
Funding organisation	Saxon State Ministry for Science, Culture and Tourism (SMWK)
Planned costs	455.342 EUR
Planned funding	455.342 EUR
Person months	27
Technology Readiness Level	project start: 2 project end: 4
Contact Person	
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Exclusion of evaluators	

Partner 2	
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Legal name	CENTRUM PRE VYUZITIE POKROCILYCH MATERIALOV SLOVENSKEJ AKADEMIE VIED
NACE code	
Organisation	Centre for advanced materials application SAS (CEMEA)
Organisation type	Research org.
Department	Department for Advanced Battery Technologies
Street	DUBRAVSKA CESTA 5807/9
City	BRATISLAVA
Postal code	845 11
Country	Slovakia
Website	
Funding organisation	Slovak Academy of Sciences (SAS)
Planned costs	140.000 EUR
Planned funding	120.000 EUR
Person months	27
Technology Readiness Level	project start: 2 project end: 4
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Additional Information	
Exclusion of evaluators	

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NACE code	
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Organisation type	University
Department	Department of Materials Engineering (DEMa)
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City	SAO CARLOS
Postal code	13565-905
Country	Brazil
Website	
Funding organisation	Fundação de Amaparo à Pesquisa do Estado de São Paulo (FAPESP)
Planned costs	83.400 EUR
Planned funding	83.400 EUR
Person months	25
Technology Readiness Level	project start: 1 project end: 3
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Additional Information	
Exclusion of evaluators	

Partner 4	
PIC	999897729
Legal name	TECHNISCHE UNIVERSITAET DRESDEN
NACE code	
Organisation	Technische Unversitaet Dresden
Organisation type	University
Department	Faculty of Mechanical Science and Engineering
Street	HELMHOLTZSTRASSE 10
City	DRESDEN
Postal code	01069
Country	Germany
Website	
Funding organisation	Saxon State Ministry for Science, Culture and Tourism (SMWK)
Planned costs	195.000 EUR
Planned funding	195.000 EUR
Person months	22
Technology Readiness Level	project start: 1 project end: 3
Contact Person	
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Additional Information	
Exclusion of evaluators	

M-ERA.NET Call 2023

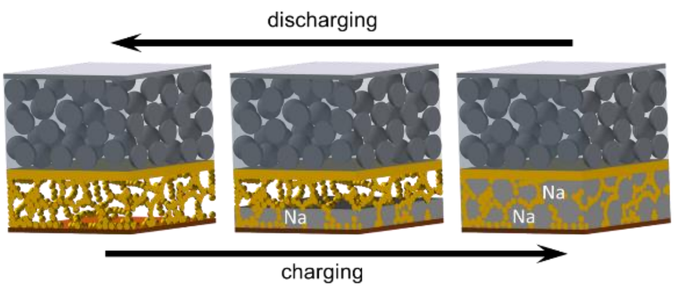
Full-Proposal

Project Acronym: Na-CerAnode

Project Coordinator:

Fraunhofer IKTS

Germany



Content

1. SUMMARY

<table>
<tr><td>Project Acronym</td><td colspan="7">Na-CerAnode</td></tr>
<tr><td>Proposal Long Title</td><td colspan="7">Ceramic Anode Host Material for Confined Sodium Plating</td></tr>
<tr><td rowspan="2">Project Coordinator</td><td>Name:</td><td colspan="6">Dr. Kristian Nikolowski</td></tr>
<tr><td>E-mail:</td><td colspan="6">kristian.nikolowski@ikts.fraunhofer.de</td></tr>
<tr><td>Coordinator Organisation
(full name in original language / name in English)</td><td colspan="3">Fraunhofer Institut für keramische Technologien und Systeme IKTS
English: Fraunhofer Institute for Ceramic Technology and Systems IKTS</td><td colspan="2">Country/ Region</td><td colspan="2">Germany / Saxony</td></tr>
<tr><td rowspan="3">Address</td><td colspan="3">Winterbergstr. 28</td><td>Tel:</td><td colspan="3">+49 351 2553-7267</td></tr>
<tr><td colspan="2">Postal code (CEDEX)</td><td>01277</td><td>Fax:</td><td colspan="3">+49 351 2554-176</td></tr>
<tr><td>City</td><td colspan="2">Dresden</td><td>www:</td><td colspan="3">Ikts.fraunhofer.de</td></tr>
<tr><td>Total Project Costs (Euro)</td><td colspan="2">853.000</td><td colspan="2">Requested Funding (Euro)</td><td colspan="3">853.000</td></tr>
<tr><td>Planned starting date</td><td>01.07.2024</td><td>Duration (in months)</td><td>36</td><td>Total person months</td><td colspan="3">114</td></tr>
<tr><td rowspan="6">Call Topic</td><td>☒</td><td colspan="6">Sustainable advanced materials for energy</td></tr>
<tr><td>☐</td><td colspan="6">Innovative surfaces, coatings and interfaces</td></tr>
<tr><td>☐</td><td colspan="6">High performance composites</td></tr>
<tr><td>☐</td><td colspan="6">Functional materials</td></tr>
<tr><td>☐</td><td colspan="6">Advanced materials and technologies for health applications</td></tr>
<tr><td>☐</td><td colspan="6">Next generation materials for advanced electronics</td></tr>
</table>

Publishable Abstract

Needs to be addressed

New battery technologies are needed that can be efficiently manufactured from abundant or recycled materials, have a long life, meet the performance requirements of the application and are designed to be viable and effectively recyclable. These technologies are essential to support global growth in the renewable energy sector.

Objectives

To develop processes for a novel anode for sodium-ion batteries using a porous solid separator. Improve the performance of the anode by depositing ALD layers within the porosity and applying advanced characterization technologies. Proof of feasibility in a demonstration cell.

Potential applications

Sodium-ion batteries for stationary energy storage, and small cost-effective electric vehicles.

Impact and potential benefits

Improve ecological impact of sodium-ion batteries by applying the new anode concept. Developed novel processes for next-gen batteries are of interest for engineering industry or battery cell manufacturers.

Publishable Contact Details

I agree that the coordinators contact details (name and e-mail address) will be published

Yes ☒

No ☐

Project Summary

Generation 5 Sodium-based batteries (SIB) are an emerging technology. They are **safe**, **cost-effective**, and rely on **abundant elements** and are thus a promising alternative to lithium-ion batteries (LIB). However, their limited gravimetric but in particular volumetric energy density hinders them to become a lead technology for mobile energy storage. Efforts are needed to **improve energy and power density, fast-charging capability, and lifetime, as well as to reduce manufacturing costs and enable full recyclability.** The project *Ceramic Anode Host Material for Confined Sodium Plating – Na-CerAnode* solves these issues by developing a substrate with a designed open porosity for sodium metal storage as a physical host anode, providing the requirements for a homogenous distribution of plated sodium. The design concept enables anodes with **negligible volume change** during cycling, high specific capacity of **1000 mAh g^{-1}** and **high safety**. The project develops advanced FLASH-sintering technology to reach high ionic conductivities on component level of **at least 0.5 mS cm^{-1}** while preserving the designed open porous structure at a **reduced energy and time demand**. Interfacial surface design by an electronic conducting atomic layer deposition (ALD)-coating in the open porous structure enables **fast charging at 5 C** and a high sodium cycling efficiency for application as a **zero excess ("anode free") sodium metal battery** (SMB). This ambitious aim of an open-porous, ion- and electron-conducting ceramic structure being the host for metallic sodium anodes can only be achieved through close co-operation between the partners involved.

The project is further aided by **advanced operando characterization** to clarify sodium nucleation and stripping/plating processes. To reach these targets, the project will develop and adapt tape-casting technology to sinter porous glass ceramic and ceramic sodium-ion conductor substrates (**TRL 2 → TRL 4**), FLASH-sintering technology (**TRL 1-2 → TRL 3**), ALD coating of porous inner surfaces (**TRL 2 → TRL 4)** and demonstrate a full cell based on the physical anode concept (**TRL 1 → TRL 3**). It will address a **circular economy** (such as repair, remanufacturing, recycling) for batteries with the new anode material, derive a **recycling concept** based on LIB recycling, and provide a first **techno-ecological analysis (TEA)**. The project is thus in line with sustainability, and **Responsible Research and Innovation (RRI)** requirements and will support open science. *Na-CerAnode* will provide **support for the whole innovation chain**. After validation of the *Na-CerAnode* concept at TRL 3-4, the economic risk associated with further development can be shouldered by companies i.e., the obtained knowledge can be transferred to subsequent joint research projects between academia and industry empowering European, and possibly, Brazilian companies in the market of battery production. The project will **support the European Green**

Deal by increasing attention to clean energy technologies and future batteries by proposing a next-generation battery principle, which avoids the use of rare and conflictive resources, such as lithium. The project also **supports the achievement of Sustainable Development Goals**, in particular SDG 7 ("Affordable and clean energy") by focusing on an energy storage technology, that is both *affordable* by using abundant raw materials and *clean* through energy savings during production, by increasing long term stability, and simplifying recycling strategies. This also contributes to **socio-ecological benefits in the context of RRI**, since the establishment of a sustainable energy storage infrastructure is of socio-ecological, ethical and political dimensions.
Na-CerAnode strengthens the international cooperation and thus joins the technological and scientific potential of three participating countries / regions (Germany / Saxony, Slovakia and Brazil / Sao Paulo) to increase the competitiveness of European and South Americas science and economy.

2. CONSORTIUM OVERVIEW

CONSORTIUM OVERVIEW					
Organisation	**Partner name (Full name)**	**Coordinator: IKTS (Fraunhofer Institute for Ceramic Technologies and Systems IKTS)**	**Partner 2: CEMEA (Centre for Advanced Materials Application)**	**Partner 3: LaMaV (Vitreous Material Laboratory of Federal University of São Carlos)**	**Partner 4: TUD (Technische Universität Dresden)**
	Participation Identification Code (PIC)	**999984059**	**910702834**	**999889096**	**999897729**
	TRL at project start	2	2	1	1
	TRL at project end	4	4	3	3
	Organisation Type	RES	RES	HE - University	HE - University
	Website http:	www.ikts.fraunhofer.de	http://www.cemea.sav.sk/en/	https://www.ufscar.br/ https://www.certev.ufscar.br/en http://lamav.weebly.com/	https://tu-dresden.de/ing/maschinenwesen/ifww/anw
	Region / Country	Saxony / Germany	Bratislava/Slovakia	São Carlos, S.P., Brazil	Saxony / Germany
	Organisation registration number	DE 129515865	SK 2120595257	09.342.433/0001-08	DE 188369991
	Size (Employees)	N/A	N/A	N/A	N/A
	Turnover (K€)				
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	Funding Programme (full name)	RL EuProNet (Richtlinie des SMWK zur Gewährung von Zuwendungen für Maßnahmen im Rahmen der wettbewerblichen EU-Förderprogramme für Forschung und Innovation)	Funding of the international research and development cooperation (MVTS).	M.ERA-NET partnership	RL EuProNet (Richtlinie des SMWK zur Gewährung von Zuwendungen für Maßnahmen im Rahmen der wettbewerblichen EU-Förderprogramme für Forschung und Innovation)

3. EXCELLENCE

3.1 Objectives of the project and expected results

The project *Na-CerAnode* proposes a porous ceramic material as a physical host anode for sodium metal plating in a confined space. It is in line with the call's topic 1 objectives addressing active materials and electrolytes for generation 5 batteries for mobile applications, addressing furthermore safety, processing technology and RRI requirements. The project specific objectives are defined in the following table:

Table 1: Objectives of the project and expected results.

Specific Objectives	Expected results/KPIs
(1) Porous host material for sodium storage	• Host anode that allows battery cycling with negligible volume change (**$\Delta V = 0$**) at the cell level • Solid electrolyte substrates with **70% porosity** • High-capacity anode with **1000 mAh/g** and **800 mAh/cm^3** physical storage capacity for sodium metal[1] • High **safety** metal anode; in particular, the confined sodium plating enables cell safety at $T > T_m$ (> 98°C).
(2) Sintering of a sodium ion conductor	• Advanced sintering technology (FLASH sintering) for combined porous and dense sodium-conducting rare earth silicate-type glass-ceramic and NaSICON solid electrolyte substrates • Design of open porous structures for homogenous distribution of metallic sodium in the anode host • Ceramic and glass-ceramic sodium ion conductors with **> 0.5 mS/cm** by Flash sintering and Flash Sinter-Crystallization
(3) Advanced surface properties	• High-rate capable material allowing **5C (12 minutes)** fast charging (Na-plating) based on improved surface wetting by ALD-coating inside the porous host structures. • Highly wettable artificial SEI enables **high initial coulombic efficiency (> 90%)** for application as a zero-excess sodium metal battery
(4) Advanced operando characterization	• Sodium nucleation mechanism by operando microscopy • Evolution of stresses during Na-plating/stripping by synchrotron X-ray diffraction • Pore filling mechanism and cell breathing by operando dilatometry
(5) Sustainability and RRI	• Anode for Lithium-free Gen 5 sodium batteries (avoidance of critical raw materials) • Energy efficient FLASH sintering process for the synthesis of solid electrolytes and for a new synthesis route for the *Na-CerAnode* • recycling concept for critical and strategic elements (Zr, rare-earth) in conventional LIB recycling routes or alternative recycling routes • techno-ecological analysis (TEA) to estimate environmental impacts.

[1] This will improve the energy density of a Sodium-Ion battery, since 800 mAh/cm^3 is more than two times higher than hard carbon anodes which show 300 mAh/cm^3 (https://doi.org/10.1039/D0TA07687B), thus enabling higher energy density full cells. Nevertheless, the energy density of a full cell is dependent of additional materials, components, and cell design parameters which are outside of the scope of the *Na-CerAnode* proposal

- Concepts regarding a circular economy (such as repair, remanufacturing, recycling) for batteries with the new anode material.
- Open science

3.2 Concept and approach

In *Na-CerAnode,* a new anode concept enabling high performance SMB is to be developed. To achieve the goals of *Na-CerAnode*, the following interdisciplinary approach is being made:

- Tape-casting of sodium-conducting rare earth silicate-type glass ceramics and NaSICONusing sacrificial pore-forming agents to form a defined open porosity, pore morphology and size distribution after sintering.
  TRL 2 → TRL 4 (IKTS)
- Advanced sintering using the FLASH method.
  TRL 1 → TRL 3 (LaMaV)
- Surface coating of highly porous materials by means of ALD technology.
  TRL 2 → TRL 4 (CEMEA)
- Assembly of laboratory zero-excess SMB cells with porous host anode.
  TRL 1 → TRL 3 (TUD)

The development of physical host anodes will be based on established room temperature Na-ion conductor materials sodium-rare earth silicate-type glass ceramics and NaSICON (general designated as solid electrolytes) with ionic conductivities > 0.5 mS cm^{-1}@RT (material level). The porous host scaffold will be prepared by the ceramic shaping technology called tape casting which allows flexible and scalable manufacturing of planar substrates. The sinterable glass-ceramic solid electrolytes developed by IKTS are at a TRL level of 2, whereas NaSICON is already being offered by specialized companies (e.g. Nexceris, US) as powders with an experimental character at a TRL level of 5-6. The critical design parameters to achieve high areal loadings while preserving high volumetric energy density are porosity and thickness (Fig. 1, bottom right). The thickness can be adjusted directly by tape-casting parameters or lamination of different tapes. To adjust porosity, pore morphology and size distribution, tailored pore-forming agents are added during the production of a tape casting slurry. Liquid-based pore formers will allow to preserve porosity during drying of the tapes. Besides, polymeric pore formers will be tested. During tempering or direct sintering, the polymers will be decomposed, leaving behind a conductive carbon film that benefits homogeneous growth of Na inside the pores.
Dense and porous films will be further processed using FLASH sintering. Flash sintering is an ultrafast sintering method capable of densifying ceramic materials in a matter of seconds at considerably lower furnace temperatures when compared to conventional methods.[8] This process involves applying an electric field directly to the ceramic sample while heating it. At a critical combination of electric field and temperature, a so-called *thermal runaway event* occurs, triggering a self-sustained feedback loop of rise in conductivity, temperature, and electrical current passing through the sample.[9] Recently, flash sintering has been used not only for sintering but also to accelerate solid-state reaction and sintering in a single step, a process called reactive flash sintering.[10,11] Studies have shown that flash sintering process can be used to crystallize glasses into NaSICON glass-ceramics in a matter of seconds, achieving higher ionic conductivity than conventional methods.[12] In *Na-CerAnode,* we will use flash sintering to perform sintering and crystallization of porous and dense tapes. Our hypothesis is that flash sintering can be used for both sintering and joining the tapes while preserving the pore morphology and size distribution set by the tape-casting process.
To improve the electrochemical kinetics and ensure complete filling of the pores during Na-plating, the inner surface of the porous host anode will be modified by atomic layer deposition (ALD). The inherent self-limitation of ALD technology allows unprecedented control of the layer thickness

within the physical anode host. Initially, selected ALD layers, starting from Al_2O_3, ZnO, and TiO_2 will be applied to planar substrates to study the nucleation overpotential and Na-plating stripping behavior compared to pristine substrate. After identification of the most suited material, porous films will be used, and the deposition conditions will be optimized.
The host structures produced in this way are used to manufacture anode symmetrical cells and half-cells to study sodium stripping/plating as well as Na nucleation, respectively. Furthermore, an anode-free SMB will be demonstrated. For this purpose, the physical host anode will be combined with an established, conventional cathode that is infiltrated by a liquid electrolyte. These cells will be characterized by their electrochemical performance to elucidate any interrelationships between materials, processing, structure, and final properties. Furthermore, all developments are supported by advanced characterization of the Na-plating and stripping behavior. Operando optical microscopy on planar model substrates will be employed to investigate the nucleation density and kinetics. SAXS will be used to track the pore filling/emptying in real time. Operando synchrotron-based 2D X-ray diffraction can monitor the stress distribution within the porous scaffold during Na plating/stripping. Ex-situ cross-sectional SEM imaging combined with EDS analyses at different states of the pore filling process as well as operando dilatometry[13] will be performed to study the (non-)breathing behavior of the cell during Na-plating and stripping. The impact of host properties, such as pore morphology and size distribution, microstructure, and functional surface layers on the Na-plating and stripping behavior is studied by means of electrochemical impedance spectroscopy and chronoamperometry to support the understanding of effects on the cycling stability and fast-charging capability.
The combination of innovative structuring and sintering and advanced characterization will allow *Na-CerAnode* to achieve its ambitious project goals. Finally, the obtained insights and performance data will enable to evaluate *Na-CerAnode* technology in terms of battery properties, environmental friendliness, cost efficiency (e.g., in $/kWh), supply security and recyclability. The concept and approach of *Na-CerAnode* contribute to sustainability and RRI requirements described for topic I. By developing a high energy anode for SMB, the project closes the gap between SoA SIB and requirements for high performance automotive application. The project thus supports the transition to a lithium-free e-mobility. Advanced sintering technology like FLASH sintering will help to reduce the energy demand in the production process. A ceramic anode is long living at a low degradation grade. The concept avoids dendrite formation by design, thus enabling high cycle-life at high performance. Based on the anode concept developed in *Na-CerAnode* a recycling strategy for Na-based batteries with ceramic host anodes will be developed with the aim to identify the main differences between LIBs and the developed concept to enable a sustainable recovery of strategic and critical materials like zircon and rare-earth metals present in the ceramic component. With the obtained data and findings, we will be able to perform a first techno-economic analysis (TEA) of the hybrid concept to evaluate its suitability for the circular economy and compare it with established energy storage technologies.

3.3 Ambition

Na-CerAnode aims to develop a high energy anode for **Generation 5 sodium-metal batteries (SMB)**. Gen 5 sodium-ion batteries (SIB) recently became commercialized by CATL[2] and Faradion and Chinese car makers announced their first models based on this technology. State-of-the-Art (SoA) cells by CATL already exhibit gravimetric energy densities on par with LFP-Lithium-Ion battery (LIB) technology but at a reduced volumetric energy density. SIB exhibits a high potential in cost reduction since components are based on abundant elements only. Still on the material and component level there is much room for improvement regarding e-mobility

[2] Contemporary Amperex Technology Co. Limited

application. The anode of SoA SIBs is based on hard carbon which is a cost-efficient material but exhibits several drawbacks in view of high energy applications. In particular, the low density of hard carbon as an active material leads to low volumetric energy density. The energy density can be increased by replacing the hard carbon with sodium metal. However, the difficulty in handling and workability of thin Na foils results in high fabrication costs. **The *zero-excess* battery concept**, also known as anode-less or anode-free battery, in which the anode is formed in situ on the anode current collector (CC), is favored due to the further energy density gain, the material and cell production cost reduction and recycling simplification.[1] However, *zero-excess* SMB employing liquid electrolyte suffer from insufficient cycling stability due to the low reversibility of Na plating and stripping caused by the repeated break-up and re-formation of the solid-electrolyte interphase. In addition, the associated formation of dendrites that can penetrate the separator is a considerable safety risk due to the danger of short circuits.[2] Replacing the separator by a dense (glass)-ceramic enables stable operation of SMB, still, the planar interface and interfacial issues with pore and dendrite formation at high rate stripping and plating limit cell performance to low cathode loadings and low rates, which is far below the specifications of a mobile energy storage application. In the case of lithium metal batteries (LMB), **porous host structures** were demonstrated to enable fast lithium stripping and plating.[3] Porous LLZO solid electrolyte structures act as a physical anode for lithium storage. The specific capacity is determined by its weight and the lithium storage capacity of the void space. Reported LLZO scaffold exhibits up to 70% porosity.[4] Despite the high density of LLZO an anode capacity of 1000 mAh g^{-1} can be achieved. This way, physical host anodes allow lithium plating in a constrained volume and thus without thickness change upon cycling, helping to circumvent mechanical stress within a cell. Recently, first Na/S batteries with self-supporting $Na_5YSi_4O_{12}$ scaffolds as the solid-electrolyte-separator have been demonstrated, showing the transferability of this approach towards Na-based batteries.[5]

It is obvious that the porosity itself as well as the pore morphology and size distribution have a major influence on the functionality and reversibility of Li/Na plating/stripping. Accordingly, shaping and sintering of the solid-electrolyte-separators is key to enabling excellent battery performance. **Macro-porous ceramics with tailored porosity** offer a great deal of advantage in wide-ranging industrial applications including fluid filtration, thermal insulation and lately, wastewater treatment. With the pore forming agent method, porous ceramics with decently controlled pores can be developed through the inclusion of porogen agents and ejecting them out by sublimation, chemical leaching or by burning them out. Various pore forming agents are available, classified as (I) synthetic organic (polymer beads, fibers), (II) natural organic (potato starch, cellulose, cotton), (III) metallic and inorganic (nickel, carbon, fly ash, glass particles) and (IV) liquid (water, gel, emulsions).[6] However, such methods were not applied in the context of ceramic solid electrolyte based battery components so far.

Since the solid electrolyte does not conduct electrons, it is questionable so far whether the pores can be filled completely and if a homogeneous Li/Na deposition can be achieved. To guide Li/Na deposition in zero-excess batteries, the integration of **functional layers** has been proven most promising.[4] Among the different methods possible, atomic layer deposition (ALD) has turned out very effective to increase the wettability and nucleation density of Li/Na metal and to act as a protective film (or artificial SEI) with improved electrochemical stability, while being a well-scalable manufacturing technology at the same time.[7] The advantage of ALD method for modifying the nanoporous materials is that, in contrast to many other PVD/CVD methods, the saturation and self-limitation of the reactions leads to covering even deeply buried surfaces of pores with a uniform film. Nevertheless, to date, ALD coatings have not been applied in the context of physical host anodes for solid-state sodium batteries.

Summarizing, the concept of using a physical host for sodium plating as the anode in zero-excess SMB appears very promising, but there are still challenges to overcome to achieve sufficient performance for application in electromobility. This includes, above all, a fundamental understanding of the deposition and stripping behavior of sodium within the physical host anode and, based on this, an appropriate design of the solid electrolyte separator/host as well as the development of suitable but also sustainable shaping and sintering processes that allow scalable production.

Progress of *Na-CerAnode* beyond the state-of-the-art:
In the *Na-CerAnode* project, we propose the concept of a physical host anode with improved surface properties and advanced sintering technology. **The technology allows for designing a physical anode with energy density superior to SoA hard-carbon or sodium-metal, while avoiding volume changes at the cell level during battery operation** (Fig. 1, top).

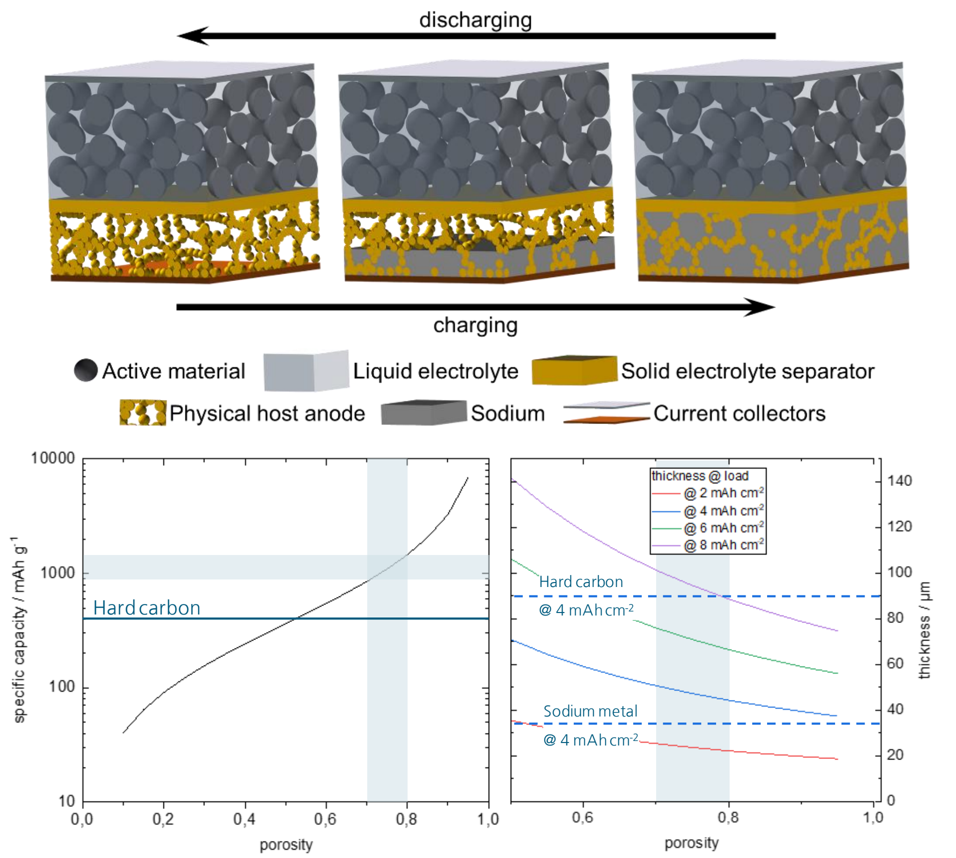


Figure 1: Sodium filling concept the physical host anode (top); evolution of the specific capacity and host thickness with increasing porosity of the host anode. The targeted porosity corridor is marked as blue box. SoA hard carbon and sodium metal were added for comparison.

By using light weight Na-ion conductors (density ~3 g cm^{-3} in contrast to LLZO-density ~ 5.5 g cm^{3}) as host matrix, the specific capacity of the anode can be increased dramatically. By appropriate designing of the host structure (porosities of 70% to 80%), capacities of 1000 mAh g^{1} become feasible, which is much larger than SoA hard carbon (~400 mAh g^{-1}) and can compete with lithium-ion technology (Fig. 1, bottom left). Appropriate design and sustainable production of the host structures will be realized by innovative shaping and sintering technologies including sacrificial shaping additives combined with FLASH sintering. The host concept allows battery operation without volume changes and associated mechanical stresses at the cell level. Due to the higher molar volume of sodium compared to lithium, anode breathing is much more pronounced in SMB. At a 4 mAh cm^{2} cell loading sodium plating on a flat current collector will cause a volume change of at least 35 µm per cell layer, assuming a completely dense and homogenous deposition. A host structure will be only slightly thicker but at a fixed volume of 45 µm (Fig. 1). This is half the thickness of a conventional hard carbon anode (90 µm) with similar areal capacity. The physical host anode provides increased safety compared to SoA SIB anodes due to its ceramic, non-flammable character. The confined sodium plating will provide additional safety at over-temperature beyond the melting point of sodium ($T > T_m(Na) = 98°C$) since it is kept in place and will not short circuit the cell as possible in case of SMB. To increase the wettability of the solid electrolytes by sodium metal, the sodium | solid-electrolyte interface will be properly designed by ALD-coating technology. The high inner surface of the porous structure with improved surface properties will allow fast charging at 5C without dendrite formation. High initial coulombic efficiencies of more than 90% allow a zero-excess SMB design where all the sodium is stored in the cathode upon cell assembly. The avoidance of additional metallic sodium upon cell assembly drastically simplifies the manufacturing process, safety, and cost. Accordingly, SMB based on *Na-CerAnode* technology will surpass state-of-the-art LIB in terms of energy density (driving range), rate performance (fast charging), safety, environmental friendliness, cost efficiency (e.g., in $/kWh), supply security and recyclability.

4. IMPACT

4.1 Contribution at the European or international level to the expected impacts listed under the selected call topic

SIBs are still in the early stages of commercialization. Leading in the development are the Chinese company CATL, the world's largest battery manufacturer, and Faradion (UK, now acquired by the Indian company Reliance). Sodium battery technology has the potential of being low cost by avoiding critical elements. The biggest difficulty of the technology lies in the anode. International competitors currently still have a development advantage here. However, by developing an alternative anode technology in the *Na-CerAnode* project, this advantage can be offset by a simultaneous gain in performance. Through developments at the material and component level, Europe can take over the technological leadership here. This will result in unique selling points for licensees of this technology and have a huge impact on distribution of revenues along the whole product value chain.

The project partners create the following results at the end of the project that contribute to the expected impact of the call.

Table 2: Project results and its contribution for long term impact

Partner	Result	Impact
IKTS	• Tape casting formulations and recipes for (ion conducting) solid electrolyte substrates with designed porosities. • Evaluated concept for a novel, high energy density anode • Sustainability considerations through process control (flowsheet) by identifying key parameters and a tentative LCA. • Recycling approach suggestion including challenges to be addressed	• Manufacturability of metallized, porous scaffolds made of (glass)ceramic solid electrolytes enabling a flexible use of metallic sodium as anode • Design of new, low expansion, stable solid-state concepts • LCA will demonstrate the sustainability of the *Na-CerAnode* concept and also of Na-batteries making the implementation more attractive for industry
CEMEA	• Application of nm-thick electron conducting coatings in porous ceramic structures by Atomic Layer Deposition (ALD).	• Improving the competitiveness of Na-batteries on the market due to wetting ALD layers.

	• Tuning the nucleation density of ALD coatings using an *operando* optical top-view cell. • Evaluating chemo-mechanical stresses via *operando* synchrotron X-ray diffraction.	• In-depth understanding of the kinetics of Na plating and the spatio-temporal distribution of chemical-mechanical stresses in the engineered porous anode, thereby improving the impact of research activities.
LaMaV	• Successful sintering and bonding of bilayer solid electrolyte tapes with dense and porous layers will be achieved using a highly energy efficient flash sintering technique. • Identifying an optimal process parameter range that results in high ionic conductivity (>0.5 mS cm^{-1} at room temperature) and suitable mechanical bonding between the dense and porous solid electrolyte host anode. • Efficient one-step debinding and sintering process for the porous layer, streamlining production and reducing processing time.	• Equip industry sectors (i.e., energy storage, sensors, electronics) with a highly energy efficient and ultrafast method for sintering and bonding ceramic films • Increase the competitiveness of ASSB by facilitating streamlined production, reducing costs and processing time. • Improved product performance, leading to increased market competitiveness. • Enhanced productivity and resource efficiency
TUD	• Advanced characterization of nucleation and Na plating mechanism • Identifying favorable surface coatings leading to improved coulombic efficiency • Transfer of optimized Na host structures to the full cell level	• Deeper understanding of nucleation kinetics and growth of anodes will help to evaluate design strategies • Optimized design parameters will lead to improved cyclability • Validation of optimized strategies in full cells will increase the competitiveness of ASSB • Fast feedback of the results on the battery level to the project partners to support the design and modification of solid electrolyte host anodes

- **Scientific impacts**

Na-CerAnode aims to develop a high energy physical host anode for sodium-metal storage allowing new energy storage systems with higher efficiency, improved overall performance and lower cost. It is expected that the first-time demonstration of the electrochemical performance and elucidation of the operating mechanism will have a tremendous impact on the scientific community and stimulate other researchers and industry to intensify the research. The main scientific benefits of the proposal are:

- Experimental assessment of the relationship between tape-casting, sintering-technology, and substrate morphology
- Structure-property relationships between pore-structure, interfacial design, and sodium stripping-plating behavior
- Demonstration of a zero-excess sodium metal battery

To further engage with scientific user groups, at least eight open-access publications are planned to be published within the duration of the project. Through IKTS' participation in the Batteries European Partnership Association (BEPA), representing the research side of the BATT4EU partnership, we will integrate the European battery community ready to contribute to the ambitious Horizon Europe research and innovation partnership for batteries. Participation in trade fairs and scientific conferences will further increase *Na-CerAnode's* visibility to the scientific community and external stakeholders, which will be described in detail in the dissemination and communication plan. The project will support the training of young scientists (e.g., Master thesis, PhD students, Post-Docs). Knowledge transfer will be integrated into teaching by the university partner.

- **Economic impacts**

As a long-term outcome of the project, know-how of future battery concepts in Europe will be generated, strengthening the position of the European Union as a battery manufacturer and technology leader for the post-lithium era. If successful, the developments will pave the way to a sustainable value chain for sodium batteries. By proper IP management Europe and partner countries can thus gain an advantage over international competitors and strengthen their industrial leadership in the battery sector. The developments in *Na-CerAnode* are aiming for high power batteries with sufficient energy density for modern EVs. The use of abundant resources compared to conventional LIB and the avoidance of lithium will reduce dependence on critical markets and strengthen the European Union's self-reliance. After validation of the *Na-CerAnode* concept at TRL 3-4, the economic risk associated with further development can be shouldered by companies. Thus, after the successful completion of the project, the aim is to transit the findings to higher TRL with an industry-led follow-up project (e.g., public funding) or to support European companies directly as an R&D-partner. The area of cooperation ranges from material manufacturers to machine and plant manufacturers to cell and module manufacturers.
The economic benefits for R&D partners should result from licensing of patents and know-how for manufacturing process and material combinations as well as from technology transfer with industrial partners. The leading role in the development of SMB will support building up the whole value chain of sustainable high-energy batteries in Europe.

- **Societal and environmental impacts**

The project will support the European Green Deal and the SET-Plan by increasing attention to clean energy technologies and future batteries, proposing a next-generation battery principle, which avoids the use of rare and conflictive resources, such as cobalt and lithium. The project also supports the achievement of Sustainable Development Goals, in particular SDG 7 ("Affordable and clean energy") by focusing on an energy storage technology, that is both *affordable* by using abundant raw materials and *clean* through energy savings during production (e.g., reduced sintering time by FLASH in range of minutes) and by increased durability (3000+ cycles) and simplified recycling. This also contributes to socio-ecological benefits in the context of RRI, since the establishment of a sustainable energy storage infrastructure is of socio-ecological, ethical, and political dimensions. In specific relation to the SET plan, *Na-CerAnode* will help integrate renewable technologies in the energy systems, as it offers a low-cost battery concept of Gen. 5, which is not only suited for mobile application but also a candidate for stationary storage and grid balancing of renewable energies. Thereby, the resilience of energy systems will be strengthened. The project will reduce the costs of technologies and raise competitiveness in the global battery sector and e-mobility as it will reduce the EU's dependency on critical raw materials imported from third countries. The strengthening of the European battery industry will further lead to increased job opportunities. The *Na-CerAnode* team will train and educate young people and students in novel battery technology, providing skilled personnel in this innovative area. Sharing knowledge among people inside and outside the battery community is one of the goals of *Na-CerAnode*, thus maximizing outreach and impact. The project will finally support the strategic objectives of European policy with regard to the reduction of greenhouse gas emissions and the development of affordable energy sources and use. The project will furthermore strengthen the innovation excellence of the participating European universities and research institutes.

4.2 Significance of the project results and user benefit

IKTS

The application as a porous host anode is a new field of application for the Sodium solid electrolytes. New expertise on processing slurries with foaming agents and tape cast those, with appropriate additives and casting parameters will be generated. The manufacturability of such components using flash sintering with LaMaV is expected to result in higher throughputs as well as improved possibilities for combining porous and dense structures and the targeted adjustment of porosities. Being able to combine a dense and a porous ceramic sintered layer by free conventional sintering would be a huge step for a new era of battery concepts requiring metallic sodium for enhanced energy densities (e.g. all solid state – ASSB; Sodium-Sulfur, Sodium-Air). Therefore, the project results will increase the activities of Fraunhofer IKTS in the field of novel energy storage technologies. The specific know-how regarding the applicability of the novel porous sodium-anode strengthens IKTS potential as a partner for future cooperations with industrial companies or in research projects. Regarding the recyclability and sustainability activities, including those in such an early stage provide the opportunity to iterate and validate the manufacture process considering from the beginning the recycling and circularity aspects. Therefore, the project results will provide data and facts with the life cycle assessments to evaluate the sustainability of the suggested *Na-CerAnode* concept.

CEMEA

CEMEA's current expertise is focused on the application of ALD coatings exclusively to Li-ion batteries. The planned collaboration within *Na-CerAnode* will be a major step towards new research opportunities. In addition, the optical and X-ray *operando* techniques already developed for Li-ion batteries will be extended to Na batteries, providing a scientific benefit for CEMEA. In addition, the objectives of *Na-CerAnode* are directly related to the strategy for low-carbon development of the Slovak Republic until 2030 with a view to 2050 (SK RIS3 Strategy 2021+). This strategy sets out the Slovak Republic's vision for the development of the battery industry and identifies key priorities for action. It is aligned with the *European Green Deal* and aims to make Slovakia a leading center for the development and production of new battery technologies.

LaMaV

Within *Na-CerAnode*, LaMaV's involvement is strategically significant in the development of new knowledge related to single-step sinter-joining and debinding of dense/porous bilayer films using flash sintering. The outcomes of LaMaV's contributions will have far-reaching implications for multiple industrial sectors, including energy storage, sensors, electronics, and the scientific community:

- Advancement of sustainable and environmentally friendly manufacturing practices.
- Strengthened position as an innovative and knowledge-sharing organization.
- Enrichment of LaMaV's reputation as a partner in cutting-edge research and development.
- Reinforcement of collaborative relationships with industry and international academic groups.
- Contribution to the education and development of master's and Ph.D. students through hands-on research experience.

The newfound knowledge will be integrated by offering educational courses, delivering conference talks and publishing research findings in open-access peer-reviewed journals.

TUD

TUD has a strong background in electrochemistry using liquid electrolytes. Extending this knowledge to the use of solid electrolytes is strategically important for TUD since it will strengthen

TUD's activities in the field of solid-state battery materials in general. Using complementary methods such as operando dilatometry and CEMEA's spatially-resolved X-ray measurements is a great opportunity to deepen the understanding of the evolution of the deposited layer morphology in dependence of host porosity, conductivity and interlayer modification which is needed to determine optimized design strategies for interlayers and host structures. The acquired knowledge can then be transferred to similar cell concepts (e.g. solid state lithium metal batteries) and will help in improving ASSB in general.

Competitiveness and growth of companies (market analysis where relevant)

Sodium-ion batteries are considered a cost-effective and environmentally friendly alternative in the battery market. Their specific properties give them advantages over other battery technologies, particularly in price-sensitive markets such as two- and three-wheeled electric vehicles, EVs for low speeds, storage of energy generated from renewable sources and local energy storage in the industrial sector. In parts of these markets, they are a possible alternative to lead-acid batteries and, since they have comparable characteristics of LFP batteries, they are a possible alternative for applications where LFP batteries are used today. According to a study by Fraunhofer, global production capacity will increase to 75 GWh in 2030 (https://www.ffb.fraunhofer.de/en/press/Environment-Report-Sodium-Ion-Batteries.html). This is in line with published studies on market size. Assuming a price of 77 $/kWh (https://cleantechnica.com/2021/07/30/catl-reveals-sodium-ion-battery-with-160-wh-kg-energy-density/), a global production of 75 GWh corresponds to a sum of 5.8 billion USD, which is in line with the market size estimate (see Figure 2). This illustrates that the market for sodium ion batteries will be worth several billion USD in the coming years up to 2030.

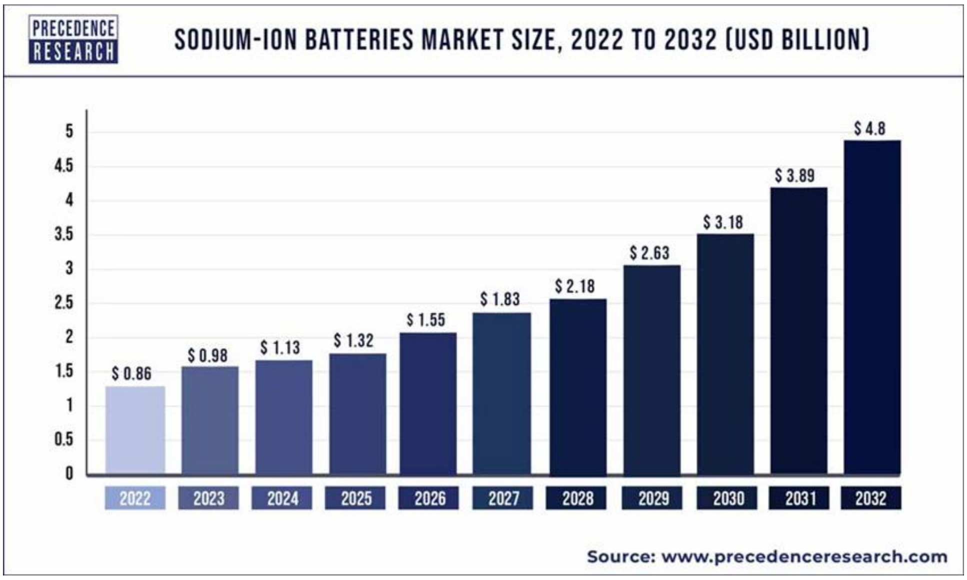


Figure 2: Expected evolution of the Sodium battery market in Billion USD (https://www.marketstatsnews.com/sodium-ion-batteries-market/).

The *Na-CerAnode* project proposes a new anode concept that further contributes to resource efficiency and improved electrochemical properties by replacing hard carbon. This makes the technology interesting for companies that are currently developing cells in sodium ion technologies and are active in the market described above, which is worth several billion USD. These companies include AMTE Power, Altris, Faradion, Tiamat Energy in Europe and HiNa Battery Tech, CATL, NGK Insulators, Natron Energy and Sodion Energy worldwide. Depending on the market size, the cells must be recycled at the end of their service life. With an energy density of 160 Wh/kg and 75 GWh/year, this corresponds to a mass of approx. 500,000 tons of cells per year, for which appropriate processes must be developed and, at a later date, recycling capacities established. Beyond cell manufacturers and recycling, the results of the project are of interest to companies in the field of ceramic film production (Kerafol, CeramTec), as well as to the mechanical and plant engineering industry, which develops and produces the production systems (powder production and processing, film casting, sintering) (EVONIK, Schott, Vibrantz (Ex. Ferro)). In the field of ALD coating technology, companies such as Beneq, which manufactures production systems for the continuous ALD coating of films, benefit.

4.3 Sustainability and RRI

Na-CerAnode aims to develop a novel battery concept that offers particular advantages in terms of durability, sustainability and recyclability. *Na-CerAnode* sustainable energy storage technology aims to reduce the amount of lithium required. Highly abundant materials with excellent cycle stability and easy recyclability will be employed to significantly reduce the carbon footprint compared to Li-ion batteries. *Na-CerAnode* addresses environmental impacts and sustainable solutions, in line with the Do No Significant Harm principle, by including a first Life Cycle Analysis (LCA). The identification of the key parameters, which have a direct impact on sustainability and the process is required to be able to proceed with the evaluation of the complete value production chain. The data needed to perform this LCA will be provided by the partners involved in WP2-4 and they will receive guidance from the partners involved in WP6 to include, modify and improve their production processes by including these sustainability and recyclability considerations. Within the scope of the project, a specific recycling strategy will be developed to evaluate the benefit of zero-excess SMB regarding circular economy. To anticipate, discuss and reflect the social, political, ethical or environmental context of the research, RRI principles are ensured through the involvement of relevant departments (legal, marketing, science council, etc.). Relevant stakeholders, and RRI experts will be invited to the bi-annual consortium meetings. *Na-CerAnode* does not directly address ethical or gender issues. Nevertheless, appropriate principles are ensured in the processing of the project. Non-discriminatory access to project information, data and results is provided during and after the end of the project through publications in high impact journals (open access) and international conferences, trade fairs, via social media and partners' websites, workshops with industry and academia, social events such as Open-Lab-Day, Girls Day, etc. The original research data will be made available in a trusted public data repository (https://fordatis.fraunhofer.de) after any intellectual property issues have been clarified. If successful, the results can be incorporated into the creation of roadmaps for future battery development and corresponding policy decisions. In any case, the project's findings will be incorporated into university teaching at the participating institutions and into the training of young scientists and technicians.

4.4 Dissemination and exploitation strategy

NaCer-Anode will be supported by the implementation of a dissemination and exploitation plan. To successfully disseminate and exploit the project’s results, target audiences in science, industry and the public will be subjected to specific dissemination activities and channels. The scientific community will be addressed by open-access publications in scientific journals and contributions at international conferences, feeding project results into teaching curricula and research. Dissemination towards industry aims at the technology transfer and participations at industrial exhibitions and workshops are planned. Moreover, newsletters for the industry advisory board will be sent. The contribution of news, press releases and videos to general and social media aims at showing benefits of the project’s results to the general public.

4.4.1 Management of intellectual property rights (IPR)

The administration of the Intellectual Property Rights (IPR) concerning the knowledge and outcomes generated within the *Na-CerAnode* project, accompanying the individual states on the use of partners' experience being before the project opening date (background IP of the partners), will be managed in the consortium agreement (CA). In general, all intellectual properties produced because of *Na-CerAnode* will belong to the project partners in a relationship to their financial and non-financial offerings to the process of that property creation. The knowledge shall belong to the partner which have developed it under the project. Where several partners shall have jointly generated knowledge and where it is not reasonably possible to distinguish their respective shares therein, such knowledge shall be jointly owned between/amongst them. The project coordinator will circulate an outline of the consortium agreement in due time. The CA will address among many other IPR issues the commercialization of the results of the project, and includes the protection of the pre-existing knowhow, the access rights to pre-existing knowhow and the rights for exploitation of the project results. The details of the CA itself will be negotiated between the partners and presented at the start of the project.

4.4.2 Dissemination activities of project results

Project results will be made available to the public domain – after patenting where appropriate – by different channels. A detailed dissemination plan will be developed during the first six months of the project.
IKTS: Targeting the research community, IKTS will publish open-access publications (Journal of Power Sources, Solid State Ionics, Journal of the European Ceramic Society, Journal of Solid-State Electrochemistry) within the duration of the project. The *International Sodium Battery Symposium*, held at IKTS, will serve as a platform to advertise the project. Further conferences targeting the scientific community are IMPC and IMILB. As project coordinator, IKTS will author regular newsletters for the industry advisory board. The general public will be informed by press releases, social media (e.g. X, LinkedIn) and public events (*Lange Nacht der Wissenschaften*, *Girls' Day*) about goals and results of the project

CEMEA: The broad range of applications of the *Na-CerAnode* project increases the likelihood of scientific and commercial success. The proposed dissemination and exploitation plan (including communication activities) will be continuously updated to ensure the appropriate use and dissemination of the project results. During project implementation, monthly project meetings will analyze opportunities to transfer exploitation strategies. A key parameter to obtain valuable feedback is to communicate and inform other researchers, potential users, stakeholders, and partners about the project design and expected outcomes from the beginning of the project. Early engagement of relevant target groups is essential to maximize the benefits for the Slovak and European battery industry and society. We plan to use the following communication channels: i) exhibitions, conferences, use of established EU communities such as BATTERY2030+, ii) well-established scientific journals, iii) patents, various events (seminars, conferences, fairs), websites, iv) press releases, social media, open lab days, presentations, media interviews, X (formerly Twitter), LinkedIn and more and v) teaching at universities, organization of the European Researchers' Night, the Long Night of Science for the public.

LaMaV: Beyond scientific articles to be published in collaboration with partners, the LaMaV team participates regularly in conferences like the Annual Meetings and Conferences from the International Commission on Glass (we recall here that one of the materials to be developed at LaMaV is a glass-ceramics), GOMD, the Glass and Optical Materials Division of the American Ceramic Society, the SBPMat, Brazilian Materials Research Society. It is also possible to propose a special Symposium at SBPMat on the *Na-CerAnode* or ASSB topics. LaMaV can count on the project being publicized by the social communications coordinator at UFSCar. Also, obtained results may be presented as seminars or converted into graduate course topics.

TUD: During the progression of the project, TUD will target publishing the results at conferences like ECS and ISE and along with the partners in open-access publications. Gained knowledge in the project will furthermore be included in lectures at TU Dresden. Results of the project will be addressed to the general public via social media (e.g. LinkedIn), press releases and public events (Lange Nacht der Wissenschaften) in close cooperation with IKTS.

4.4.3 Plans for the commercialisation of results

IKTS

Fraunhofer is Europe's largest application-oriented research organization. It is its task to bring scientific knowledge into industrial application. IKTS knowledge and skills acquired in *Na-CerAnode* on ion-conducting porous ceramic solid electrolytes, advanced electrochemical characterisation methods and enable IKTS to participate flexibly in public funded projects for the development of different new concepts of sodium batteries beyond the *Na-CerAnode* project. Furthermore, IKTS will exploit patentable results through licensing to companies. As a non-profit organization, IKTS will contribute the generated foreground IP to future industry projects to work with industrial customers on specific applications in the fields of battery material and component concepts, cell design, sophisticated electrochemical characterization methods and technology scaling. Including sustainability aspects (LCA and recyclability), IKTS will be able to show that the concept in the *Na-CerAnode* project has the potential to be implemented in industry satisfying their needs by considering the planetary boundaries.

CEMEA

Due to the lower TRL level, the results will be used mainly for scientific purposes, not commercial ones. Nevertheless, within the framework of the *Na-CerAnode* project, we will try to identify opportunities for the transfer of results and new knowledge into the production sphere. This will be done under the expert guidance of our industrial partners in the Technology Council of the CEMEA Institute of the Slovak Academy of Sciences, which has representation from the commercial manufacturing sector.

LaMaV

The Innovation Agency at UFSCar has experience with patent deposit, and company prospecting. There are already 41 startups registered startups, originating from the UFSCar Innovation Agency FAI/UFSCar also has a program to help publicizing the developed products and to prospect for companies which might be interested. São Carlos city is known for being a high-technology hub. The São Carlos Technological Park aims to boost the region's scientific and technological development, attracting companies that invest in high-technology research and development (R&D), with sustainable development.

TUD

As a non-profit organization TUD will aim to contribute scientific knowledge to future industrial projects, working in cooperation with industrial customers on material development and cell-design strategies for specific battery applications. The acquired knowledge in *Na-CerAnode* regarding the electrochemical characterization of solid-state sodium metal batteries will further extend TUDs participation in future public funded projects and give the opportunity of providing guidance for industrial partners regarding extensive battery material characterization. Additionally, TUD is among the universities with the most patents in Germany and therefore experienced with exploitation strategies of industrial property rights.

An Industry Board is set up to ensure rapid technology transfer. The board advises on the needs of the market and supports further development after the end of the project.

4.4.4 Management of research data

Internal data management

The partners of the project will exchange and discuss their project results at regular project meetings, which will take place at least twice per year. Video conferences and audio conferences permit the discussion of project results and the planning of further work steps on short-term appointments. All project documents will be stored in a specific IT project folder, managed by IKTS. The project folder has a specific architecture with repertories for contractual and technical data, and records. This folder can only be accessed by the authorized people involved in the project. All project documents and data will be archived for 10 years.

Metadata management

At the project start, a Data Management Plan (DMP) will be developed. It will be specified, which data will be freely accessible for other parties and which data will be accessible for the project partners only. *Na-CerAnode* research data will be managed responsibly and treated in compliance with the FAIR principles and Open Data exchange as a standard for the results of EU-funded research. *Na-CerAnode* will deposit data in a trusted repository (e. g. Foredatis) and provide open access through it. Each data set gets a Digital Object Identifier (DOI).

IKTS will make sure, that all results will be published open access (gold standard whenever possible) as soon as possible and in line with the defined data management plan.

5. IMPLEMENTATION

5.1 Work plan

5.1.1 Overview

The project is organized in six work packages (WP) as illustrated in fig. 3 Coordination and dissemination activities are organized in WP 1. The material related work packages WP 2 to 4 run in parallel and deliver samples to each other as well as to WP 5 that supplies electrochemical and advanced characterization of the working principle of the physical host anode concept i.e., of the sodium nucleation and the stripping-plating behavior. Aspects of circularity, end of life treatment and recyclability are addressed by a dedicated work package (WP 6). Specific contents of the work package are briefly outlined below.

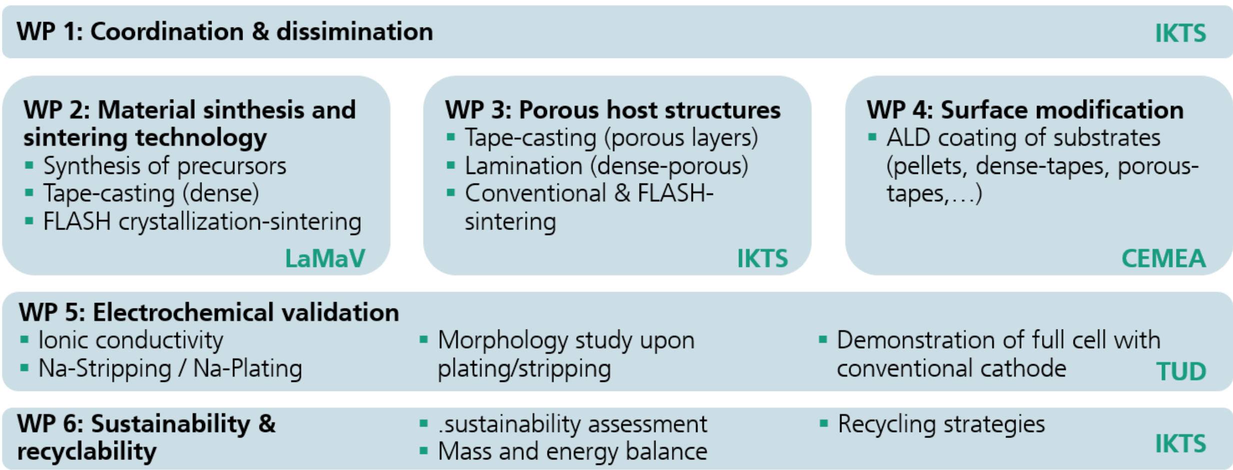


Figure 3: Work package structure and lead partner.

Table 3: Work package list

WP no.	Work package title	Work package leader	Participating project partners	Start [month]	End [month]
1	Coordination and Dissemination	IKTS	CEMEA, LaMaV, TUD	1	36
2	Materials synthesis and sintering technology	LaMaV	IKTS	1	36
3	Porous host structures	IKTS	LaMaV	7	36
4	Surface modification	CEMEA	TUD	1	36
5	Electrochemical validation	TUD	CEMEA, IKTS	1	36
6	Sustainability and Recyclability	IKTS	CEMEA, LaMaV, TUD	7	36

5.1.2 Detailed description of work package

WP number:	**1**
WP title:	**Coordination and Dissemination**
Leader:	**IKTS**
Partners involved:	**CEMEA, LaMaV, TUD**
Start date:	M1
End date:	M36
Objectives:	The project management is designed to generate a simple, flexible, and efficient instrument to ensure successful and effective collaboration and administration. Various dissemination and exploitation activities are undertaken to ensure uptake of project results during and after the project duration.
Type of activities:	Support Activity
Description of content:	**Task 1.1:** IKTS takes the responsibility for overall coordination, the administration and outreach of the project. The collaboration is ensured by an elaborated project plan, monthly in online meetings and semi-annual face-to-face meetings. IKTS will set-up a joint data exchange platform for research data exchange. IKTS monitors RRI in the project and draws the attention of all project partners to this or makes suggestions for implementation. **Task 1.2:** To ensure the uptake of the project results during and the continuation of the project after the end of the project various dissemination and communications activities are planned. Besides high-level open-access publications and conference attendances, results will be included in lectures at the universities and workshops. The general public will be informed by press releases, social media (e.g. X, LinkedIn) and public events (Open-Lab-Day, Girls' Day). For exploitation IKTS will be aware of potential IP relevant activities.
Milestones:	*none*
Expected results and deliverables:	**D1.1:** Data Management Plan (month 3, IKTS) **D1.2:** Dissemination Plan (month 6, IKTS) **D1.3:** (All): Interim and final reports (timings as required by national funding agency)

WP number:	**2**
WP title:	**Materials synthesis and sintering Technology**
Leader:	**LaMaV**
Partners involved:	IKTS
Start date:	M1
End date:	M36
Objectives:	Preparation of precursor glasses for sinter-crystallisation of conducting glass-ceramics. Procurement of commercial NaSICON powders, perform

	reference sinter-crystallization of pellet-like sample, and perform fundamental characterization of the sinter-crystallized specimens.
Type of activities:	Experimental work and supply materials for other WPs. Development of knowledge on sinter-crystallisation of NaSICON.
Description of content:	**Task 2.1:** Task 1 is dedicated to the synthesis and characterization of powder-based starting materials, with the focus on preparng highly conductive glass-ceramics. This is achieved through the synthesis of ion-conducting glass-ceramics via crystallisation of suitable precursor glass prepared using melt-quench technology. Step 1 – Precursor glass synthesis: - Employ melt-quenching technology to synthesize NaSICON precursor glasses (this glass will be used in this WP and on WP3. - Perform differential scanning calorimetry on the precursor glass to characterize its glass transition and crystallization temperature. - Optimize the process to ensure the production of high-quality glasses (bubble and crystal free) suitable for subsequent processing steps. Step 2 – Powder preparation: Grind the synthesized precursor glasses in a planetary mill to obtain fine powders with d50-values of less than 5 µm, ensuring homogeneity and optimal particle size distribution. Perform laser diffraction technique to analyse the particle sizes and distribution. Step 3 – Commercial NaSICON powder procurement: Procure commercially available NaSICON-phase powders from specialized companies (e.g., NexCeris) for comparative analysis. Ensure that the commercial powders meet the required specifications for the project. **Task 2.2:** Step 1 – Sample preparation: Press the synthesized powders and the commercial one to obtain pellet samples of 5 mm height and 6 mm diameter (isostatic pressing). Optimize the process to obtain high-green density pellet samples. Step 2 – Conventional sintering with concurrent crystallization procedure: Develop a conventional reference sintering procedure for both synthesized and commercial powder samples. Investigate by dilatometry the optimized time-temperature profiles necessary for the formation of dense and fully crystallized material. Step 3 - Flash sinter-crystallization technology for pellet-type samples: Develop and optimize flash sintering parameters to achieve simultaneous sintering and crystallization of glassy precursor pellets. Implement a systematic approach to control temperature profiles, ensuring efficient densification and formation of the desired NaSICON phase. Produce dense sintered pellets through flash sintering serving as crucial components for subsequent work packages (WP 4). Step 4 – Electrical characterization of commercial and synthesized glass ceramics:

	Perform a fundamental characterization of ionic conductivity, microstructure, and phase composition for the sinter-crystallized pellet samples. Dr. Ana C M Rodrigues, Dr. Lilian M Jesus, and Dr. Eduardo B. Ferreira are responsible for the successful implementation of both Task 1 and Task 2, Dr. Joao V Campos and Dr. Isabela R Lavagnini, and Vinicius Zallocco are involved in executing the tasks. These WP will provide insights and material for WP 4 and WP 5.
Milestones:	**MS2.1:** Obtain a Na^+ solid electrolyte with ionic conductivity > **0.5 mS cm^{-1}** at room temperature (month 24, LaMaV).
Expected results and deliverables:	**D2.1:** Flash sinter parameters to optimize the application of Flash-sintering technique to tapes (month 10, LaMaV).

WP number:	**3**
WP title:	**Porous host structures**
Leader:	**IKTS**
Partners involved:	LaMaV
Start date:	M7
End date:	M36
Objectives:	Synthesize glass ceramic powder, tape cast porous and dense layers, characterization of the tapes, conventional co-sintering of bilayer,provide green samples for LaMaV
Type of activities:	Experimental work and supply materials for other WPs
Description of content:	This work package will deal with the development of bilayer dense solid electrolyte / porous host structures for sodium plating. **Task 3.1:** The shaping technology of tape casting of ceramic suspensions is established for dense substrates (e.g. solid electrolytes). The realization of planar highly open-porous host structures is to be achieved by introducing both liquid as well as solid pore forming agents. The use of sacrificial polymer particles with defined shape and size distribution, which are burned off prior to the sintering process are established for other ceramic shaping technologies such as cold pressing. Liquid pore formers vanish within the drying process and porous green structure is directly received, without the need of eliminating polymeric additives by firing process. Different types of green tapes will be laminated to form dense-porous bilayers or porous-dense-porous tri-layers. The conventional, furnace-based sintering as established in **WP 2** will be optimized to form porous substrates with defined pore structure i.e., open porosity with defined pore sizes and distribution. A careful adjustment of the time-temperature profiles is required to inhomogeneous shrinkage or cracking of the tapes in order to keep them planar. Sintered substrates will be supplied to **WP 4** for ALD-coating and **WP 5** as reference. **Task 3.2:** Flash sinter-crystallisation as established in **WP 2** will be adapted to tapes to form porous substrates. Finally, a Flash-joining method will be developed to unify both dense and porous tapes.

Milestones:	**MS3.1:** ceramic host structure having a porosity of at least 55% produced by tape casting, equipped with an electronic conducting ALD-coating (month 18, IKTS)
Expected results and deliverables:	**D3.1:** A plane co-sintered bilayer of dense and porous layer via conventional sintering (month 24, IKTS)

WP number:	**4**
WP title:	**Surface modification**
Leader:	**CEMEA**
Partners involved:	TUD
Start date:	1
End date:	36
Objectives:	Development and optimization of ALD coatings for porous anode structures
Type of activities:	Experimental work
Description of content:	**Task 4.1:** The aim of this work package is development of coatings using atomic layer deposition (ALD). The ALD layers should allow for improved wetting of the ceramic surface by sodium metal. The following ALD coatings will be investigated: Al_2O_3, ZnO and TiO_2. Improved wettability by coatings will be studied on pellets and dense tape-like substrates obtained from **WP 2** using *operando* optical methods. **Task 4.2:** ALD will be optimized for porous substrates as developed in **WP 3**. The deposition will be performed under conditions adapted to the growth of the layers on porous materials. Coated porous host anodes i.e., as bi-layer or tri-layer structure will be provided to **WP 5**. Feedback on the successful implementation of ALD coatings will be obtained by operando measurements of chemo-mechanical stresses using synchrotron X-ray diffraction.
Milestones:	**M4.1:** Adaptation of ALD deposition for porous anode layers (month 12, CEMEA) **M4.2:** Modification of *operando* top-view and cross-section cells (month 12, CEMEA)
Expected results and deliverables:	**D4.1:** Optimized ALD coating for porous anode structures (month 24, CEMEA)

WP number:	**5**
WP title:	**Electrochemical validation**
Leader:	**TUD**
Partners involved:	CEMEA, IKTS
Start date:	1
End date:	36

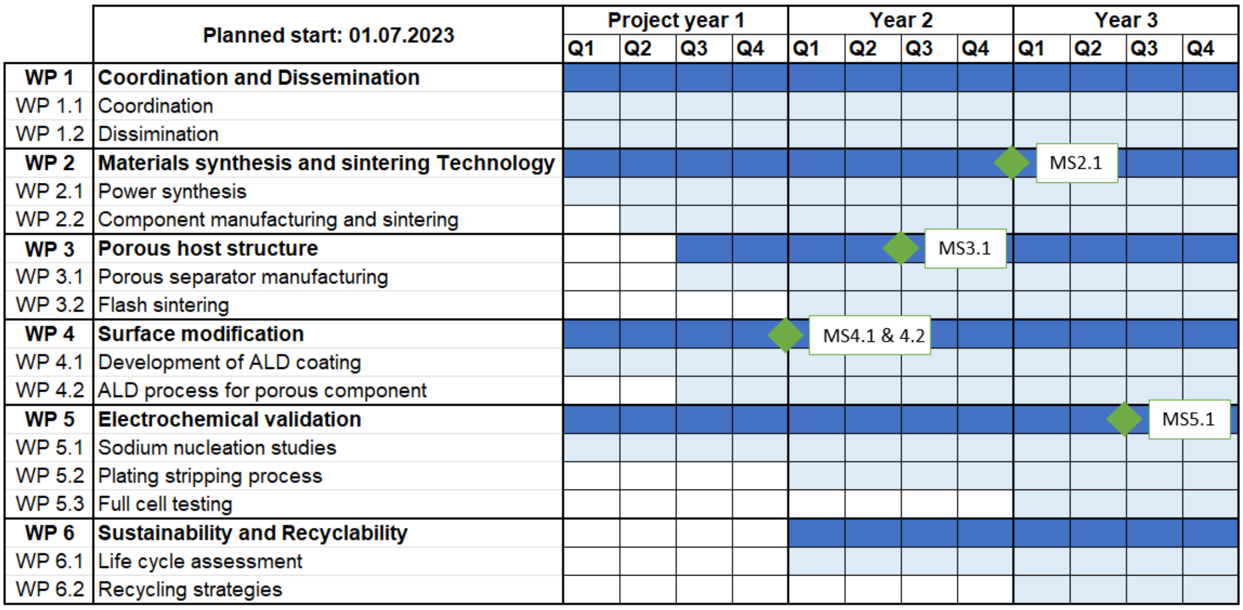
Objectives:	Characterization of nucleation and reversibility of plating/stripping of Na on surface modified structures, characterization of the pore filling process using advanced operando experimental approaches, validation of results using full cells
Type of activities:	Experimental work
Description of content:	**Task 5.1**: Sodium nucleation will be studied on planar model surfaces. Critical current density and coulombic efficiency are studied in sodium-symmetrical cells and zero-excess sodium cells, respectively. Different surface coatings will be compared. Furthermore, Advanced characterization of Na nucleation and plating kinetics is evaluated based on operando microscopy. **Task 5.2**: The plating and stripping process within the physical host anode will be studied using bi- and tri-layer structures prepared in **WP 3** and surface modified in **WP 4**. Electrochemical evaluation is done by cycling, and impedance spectroscopy and further aided by electrochemical dilatometry and ex situ electron microscopy. Operando SAXS measurements of plating/stripping and spatially-resolved X-ray stress measurements will elucidate the propagation of the pore filling process. **Task 3:** Several full cells with the best performing Na host structure and a commercial NVP cathode electrode with liquid electrolyte infiltration will be manufactured on coin cell level and tested to demonstrate the concept.
Milestones:	**MS5.1:** Plating stripping behavior was measured for 10 cycles on porous component from WP3 (month 24, TUD)
Expected results and deliverables:	**D5.1:** At least 6 full cells on coin cell level were constructed and characterized (month 32, IKTS)

WP number:	**6**
WP title:	**Sustainability and Recyclability**
Leader:	**IKTS**
Partners involved:	CEMEA, LaMaV, TUD
Start date:	7
End date:	36
Objectives:	Demonstrating sustainability of Na-batteries with ceramic host anode Embedding recycling considerations from an early stage.
Type of activities:	Definition and gathering of input data, model development
Description of content:	**Task 6.1:** Based on the anode concept developed in the project (**WP 2 to 5**), a sustainability assessment for Na-based batteries with ceramic host anodes will be developed. In a preliminary step, a complete flowsheet of the production process will be performed to track the key parameters, which control the production route. To this purpose, these parameters of each of the process steps will be defined. Afterwards, a framework LCA must be established that complies with ISO 14040 and is therefore comparable with other work. The data needed to perform the sustainability analysis will be collected with the help of all partners involved in the WP 2-4 and the tentative LCA will be continuously updated with the results produced. **Task 6.2**: Recycling strategy for Na-based batteries with ceramic host anodes will be developed. Focus will be a sustainable recovery of strategic

	and critical materials. Furthermore, the impact of the novel anode material on established recycling processes will be evaluated. Therefore, a catalog of requirements will first be drawn up and it will be checked whether the new material can be processed in conventional LIB recycling processes or whether new recycling concepts have to be developed.
Milestones:	*none*
Expected results and deliverables:	**D6.1:** Flowsheet including mass and energy balance and LCA (month 36, IKTS) **D6.2:** Report with recycling strategies for the new concept of Na-batteries with ceramic anodes (month 36, IKTS)

5.1.3 Time schedule

The following chart gives an overview regarding the project time schedule and the planned milestones.



5.2 Management structure and procedures

Management Structure
Na-CerAnode's management structure is kept lean and efficient with the primary goal to ensure the intended scientific results of the project and a trustful cooperation of all project partners. The management structure is designed to mediate efficiently between the different interests and competences of the partners while at the same time the administrative effort will be kept to a minimum. The project consortium will meet once a year in person and the project coordinator and WP leader will exchange information monthly via an online conference.

The **project coordinator** (IKTS) is responsible to meet deadlines and milestones and will ensure a high quality of documents and deliverables. The coordinator is the main contact for all stakeholders involved in the project. The coordinator will be in continuous exchange with the work package (WP) leaders. The **WP leaders** oversee the implementation of the work packages in terms of time and content. They interact daily with the **task leaders**, who are responsible for single research activities within the project.

Within the project duration of *Na-CerAnode* an **Industry Board** will be installed to give advice on exploitation activities and market needs. The industry board will be invited on demand to the annual consortium meeting to discuss about market insights and strategy building. The *Blatron Tecnologia Ltda*. (Brazil) has already signed a Letter of Support to be part of the Industry Board. Further companies have been contacted and will join the board when the project is starting.

Decision making and conflict resolution
Mandatory decision rules and agreements are necessary for the success of the project. On task level, decisions will be taken through discussion among WP leaders and participants contributing to that task. If a decision impacts other WPs, the issue will be discussed with the coordinator and the other WP leaders. In case of unforeseen or major problems decisions will be taken by the project coordinator and the WP leaders by a majority of two-thirds of the votes.

Quality assurance and risk management
The scheduling of milestones and deliverables will allow for monitoring the project evolution, (re)defining priorities and optimizing project progress by corrective measures. The project coordinator pays attention to control the compliance of the milestones. The project is aiming at a high-level of quality of its documents and other deliverables to fulfil the goals and milestone of the project, e.g. by partner peer-review and feedback by the project coordinator.

An appropriate risk assessment and management is important to ensure the timely fulfilment of challenging objectives. Project risks are susceptible to change and as such will be reviewed continuously. A draft of project risks and mitigation measures are listed in table 4. The project management will up-date the risk table on regular basis.

Table 4: Project risks and mitigation measures

WP	*Risk*	*Risk level / likelihood*	*Mitigation measure*
2	We do not achieve a dense solid electrolyte with conductivity >0.5 $mS.cm^{-1}$	Medium	Using a classical glass-ceramics, like LATP or LAGP solid electrolyte
3	Porosity of 70-80% cannot be reached	Medium / medium	Using different shaping technique (foam)
3	Plane conventional sintering of bi/trilayers not possible	Medium / medium	Load/pressure assisted sintering
3	Tape bending during flash sintering	Medium / medium	Use a non-oxide setter to keep the sample shape during sintering
4	Insufficient diffraction signal due to large battery thickness.	Low / medium	The design of the *operando* battery cell will allow the construction of batteries only 1 mm in the transverse direction.
5	Pressure less dilatometry measurements not suitable for porous structure characterization	low / medium	Perform pressure aided experiments instead
5	Electrochemical performance (e.g. plating stripping) low	low / medium	Adapt and optimize porosity network and ALD coating
6	Not enough data is generated to perform the LCA.	Medium / medium	Uptake of commercial or published data (at least for the preliminary LCA)

5.3 Quality of the individual participants

Partner 1 (Coordinator): IKTS

Role in the project: Fraunhofer IKTS will coordinate the project. Furthermore, powders and tape casting processes will be developed for porous host structures and the obtained materials are characterized. IKTS will also test the best developed anodes in a full cell with commercial cathode. Finally, a sustainability assessment will be performed, and recycling strategies will be developed.

Relevant expertise: IKTS conducts applied research on high-performance technical ceramics, and battery development from lab up to pilot scale. Fraunhofer IKTS has a strong background in ceramic ion conductors (Lithium and Sodium) as well as liquid and solid electrolyte battery technology. Three IKTS working groups participate in the project. The group *Materials and components* is engaged in research and development of glasses, glass ceramics and ceramics for different applications such as solid electrolytes, electrodes, sealing materials functional coating for cathode materials, covering various routes of material synthesis, powder preparation and sintering strategies. The group *Cell and Process Development* deals with battery material evaluation and processing, component design and manufacturing, as well as battery characterization of in house build coin and pouch cells, and commercial cells. The group is thereby strongly engaged in post-lithium-ion technology e.g., sodium based and solid-state batteries. The third group *Recycling & Green Battery* will take over the sustainability and recyclability activities with its expertise in developing recycling processes for the critical raw material recovery by including life cycle assessments.

Added value: IKTS brings to the consortium the know-how from ceramic powders, their processing to components, and the implications of material and processing parameters to the electrochemical properties and finally the performance parameters of a cell. At IKTS projects address the complete life cycle of energy storage devices from material, manufacturing, use, 2nd use, and recycling. This is experience is brought to the project consortium. Finally, the team has a long track record in the fields of material and electrochemical storage devices and is experienced in working in and managing multi partner projects.

Partner 2: CEMEA

Role in the project: The main goal of the CEMEA partner is to develop a suitable ALD coating that enables rapid Na plating of a porous anode layer. In addition, we will use our top-view *operando* cell to follow the nucleation kinetics of Na plating on ALD-modified surfaces. Furthermore, we will use synchrotron-based high-energy X-ray diffraction (HEXRD) to evaluate chemo-mechanical stress changes during galvanostatic charging/discharging (GCD) in a half-cell.

Relevant expertise: The CEMEA group has many years of experience in the application of ALD layers in electronics. Recently, we have extended our expertise to ALD protective layers for cathode and anode materials of lithium-ion batteries. In general, ALD layers improve the cycling stability of conventional Li-ion batteries. Beyond this, CEMEA has extensive expertise in the application of real-time X-ray scattering techniques to energy-related materials. Recently, we have demonstrated that HEXRD can be used to track the spatial distribution of chemo-mechanical stresses in Li-ion solid-state batteries (SSBs).

Added value: ALD technology seems to be a viable way to improve the performance of Li-based SSBs based on porous structures. In this project, we believe that this proven strategy can also be transferred to Na-based SSBs. In addition, the optical and X-ray operando methods developed by CEMEA for Li-based SSBs will be used as valuable feedback for the optimization of porous anode structures for Na-based SSBs.

Partner 3: LaMaV

Role in the project: LaMaV will apply the newly developed and energy-efficient Flash-sinter-crystallization to obtain glass-ceramics solid electrolytes. Also, this method will be used to sinter tapes obtained by tape casting, provided by the project partner TUD. These co-sintered tapes will act as the *Na-CerAnode* and possibly be joined with a Nasicon solid electrolyte.
Relevant expertise: LaMaV has expertise in glass, glass-crystalization, synthesis of Nasicon solid electrolytes by the glass-ceramics route, and their electrical and microstructural characterization. More recently, LaMaV developed flash-sinter-crystallization, which will be applied to synthesizing the solid electrolytes and the *Na-CerAnode* to be developed in the present project.
Added value: Flash-sinter-crystallization is a new method (patent-pending) LaMaV developed to obtain glass-ceramics, in which an electrical field induces the crystallization of bulk glass or glass powder pellets; because of that, sintering and crystallization occurs in furnace temperatures much lower than those necessary in conventional sintering in a few minutes or even seconds. Because of these features, the energy consumption during flash-sinter crystallization is much lower than in conventional sintering, rendering it an energy-efficient technique.

Partner 4: TUD
Role in the project: TUD will support the developments within the project by advanced characterization of the Na-plating and stripping behavior. This includes ex-situ cross-sectional SEM imaging combined with EDS analyses at different states of the pore filling process as well as operando dilatometry to study the breathing behavior of the cell during Na-plating and stripping. The impact of host properties, such as pore morphology and size distribution, microstructure, and functional surface layers, on the Na-plating and stripping behavior is analyzed by means of electrochemical impedance spectroscopy and chronoamperometry to support the understanding of effects on the cycling stability and fast-charging capability.
Relevant expertise: The research group Combinatorial Microelectrochemistry of the Chair of Inorganic-Nonmetallic Materials at TU Dresden (TUD) has many years of comprehensive experience in the field of electrochemical material characterization for batteries and supercaps using local in-situ and operando methods coupled with model-based analysis. Recent work includes the benchmarking and critical design considerations of anode-free Li- and Na-metal batteries.
Added value: Extensive electrochemical characterization on the battery level is crucial to evaluate the impact of process parameters and modification of host structures on the plating and stripping behaviour of sodium. By using complementary methods such as operando dilatometry and ex-situ cross-sectional SEM imaging and the combination with model-based analysis optimized cell design strategies and modification parameters can be identified.

5.4 Consortium as a whole

- **Complementarity and balance of the consortium including gender aspects**

The project consortium is made up of partners who can take on the tasks in the project in a suitable manner. They have unique expertise in the areas of ceramic materials and their processing (IKTS), flash sintering (LaMaV), ALD coating (CEMEA), advanced methods for characterization (TUD), testing the concept in a battery cell (IKTS) and in the areas of LCA and recycling concepts (IKTS). The business aspect and market needs are brought into the project by the Industry board set up at the start of *Na-CerAnode.*The partners thus combine their complementary skills in the project teams. Female and male scientists will work on the part of all partners (see Annex 1). The research institutions adhere to a balance concept (e.g. IKTS internal guidelines: https://www.fraunhofer.de/en/jobs-and-career/fraunhofer-as-an-employer/equal-employment-opportunities.html). The consortium includes different career levels from professors to senior scientists with leadership functions, postdocs, PhD students and technicians or laboratory technicians. Students will also be involved in the project. All genders will work under equal conditions at the various career levels (see Annex 1).

- **Inter- and transdisciplinarity character of the consortium**

In the project, two universities and two research institutes with different expertise are working together on an interdisciplinary basis. For example, there is a strong interlocking through sample exchange and joint characterization. The porous electrolyte separators produced are coated using ALD and then characterized electrochemically and in terms of battery performance. Further optimization and ultimately evaluation can only be achieved through the interdisciplinary approach. The added value for achieving the project goals is then created through discussion among the project partners beyond the knowledge from their own discipline or area of responsibility. Another example is the LCA, where the data and parameters from the individual production steps are brought together and processed on an interdisciplinary basis. Here too, the goal can only be achieved through cooperation between the partners. Transdisciplinarity is promoted in particular through exchange, e.g. at conferences with partners from other disciplines such as players at political level or with associations (e.g. Energy Saxony, Germany).

5.5 Cost calculation and resources

5.5.1 Personnel cost

Partner 1 (IKTS, Coordinator): 209,844 €. 27 Person month for scientist (22 PM) and technicians (5 PM) working on the project.

Partner 2 (CEMEA): 65,000 €. The salaries of the members of the research team are in accordance with the regulations of CEMEA SAS and the national funding agency. They include employer-provided health and social insurance.

Partner 3 (LaMaV): 44,500 € (19,500 € and 25,000 € for technician and pos-doc level researcher. Salaries of permanent staff is covered by the institution.)

Partner 4 (TUD): 179,000 € (7 PM Student, 15 PM Researcher)

5.5.2 Equipment

Partner 1 (IKTS, Coordinator): 0

Partner 2 (CEMEA): 0

Partner 3 (LaMaV): € 2,400 (Laptop to control Flash-sintering device and Doctor Blade device)

Partner 4 (TUD): 0

5.5.3 Consumables

Partner 1 (IKTS, Coordinator): 9,500 €. Chemicals for material synthesis, material for component manufacturing (binders, solvents, additives), consumables for full cell assembly and characterization (coin cell housing and components, electrolyte)

Partner 2 (CEMEA): 45,000 €. Chemical consumables for ALD layers and spare parts for X-ray scattering and optical/Raman imaging.

Partner 3 (LaMaV): € 8,800 (chemicals for the synthesis of solid electrolytes and other materials under development)

Partner 4 (TUD): 7,500 € (Chemicals for electrochemical characterization, liquid electrolytes, cathodes for full cell testing)

5.5.4 Travel

Partner 1 (IKTS, Coordinator): 7,500 €. Travel to project meetings, conferences)

Partner 2 (CEMEA): 15,000 €. Conference fees and travel reimbursement for attendance at conferences, official meetings, and measurement beamtimes.

Partner 3 (LaMaV): € 8,600 (€ 600- domestic + € 8000 (International), 4 to 5 trips to Europe to discuss results and project strategies with partner Institution)

Partner 4 (TUD): 8,500 € (Travel to project meetings, conferences)

5.5.5 Subcontracting

Partner 1 (IKTS, Coordinator): 0

Partner 2 (CEMEA): 0

Partner 3 (LaMaV): € 4,600 (materials characterization services)

Partner 4 (TUD): **0**

5.5.6 Other costs (i.e. for seminars, etc)

Partner 1 (IKTS, Coordinator): 0

Partner 2 (CEMEA): 0

Partner 3 (LaMaV): € 9,200 – Participation in International conference, and other international trips to Partner Institution

Partner 4 (TUD): 0

5.5.7 Indirect costs

Partner 1 (IKTS, Coordinator): 228,498 €. Indirect costs calculated according to SAB budgeting rules.

Partner 2 (CEMEA): 15,000 €. Conventional indirect costs account for less than 20% of total costs. They are used to cover the institute's overhead costs.

Partner 3 (LaMaV): € 5,300; Following the Brazilian funding agency demands (FAPESP), 15% of the total is allocated to Costs for infrastructure.

Partner 4 (TUD): 0

Table 5: Total project costs (only integer)

Partner	Person months	Personnel cost	Equipment	Consum-ables	Travel	Sub-contracting	Other costs	Indirect costs	Total costs	Total requested funding
		Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro
IKTS (Coordinator)	27	209,844		9,500	7,500			228,498	455,342	
		209,844		9,500	7,500			228,498		455,342
CEMEA	27	65,000		45,000	15,000			15,000	140,000	
		45,000		45,000	15,000			15,000		120,000
LaMaV	25	44,500	2,400	8,800	8,600	4,600	9,200	5,300	83,400	
		44,500	2,400	8,800	8,600	4,600	9,200	5,300		83,400
TUD	22	179,000		7,500	8,500				195,000	
		179,000		7,500	8,500					195,000
Total:	101	715,500	2,400	71,800	39,600	4,600	9,200	20,300	873,742	
		695,500	2,400	71,800	39,600	4,600	9,200	20,300		853,742

6. ETHICAL ISSUES

ETHICAL ISSUES[3]	YES / NO	Page
HUMAN EMBRYOS/FOETUSES		
Does your research involve Human Embryonic Stem Cells (hESCs)?	No	
Does your research involve the use of human embryos?	No	
HUMANS		
Does your research involve human participants?	No	
Does this activity involve interventions (physical also including imaging technology, behavioural treatments, etc.) on the study participants?	No	
Does this activity involve conducting a clinical study as defined by the Clinical Trial Regulation (EU 536/2014[4])? (using pharmaceuticals, biologicals, radiopharmaceuticals, or advanced therapy medicinal products)	No	
HUMAN CELLS / TISSUES (not covered by section 1)		
Does your research involve human cells or tissues?	No	
PERSONAL DATA		
Does your research involve processing of personal data?	No	
Does it involve the processing of special categories of personal data (e.g. sexual lifestyle, ethnicity, genetic, biometric and health data, political opinion, religious or philosophical beliefs)?	No	
If YES — Does it involve processing of genetic, biometric or health data?	No	
Does it involve profiling, systematic monitoring of individuals, or processing of large scale of special categories of data or intrusive methods of data processing (such as, surveillance, geolocation tracking etc.)?	No	
Does this activity involve further processing of previously collected personal data (including use of pre-existing data sets or sources, merging existing data sets)?	No	
ANIMALS		
Does your research involve animals?	No	
ENVIRONMENT, HEALTH and SAFETY		
Does this activity involve the use of substances or processes that may cause harm to the environment, to animals or plants (during the implementation of the activity or further to the use of the results, as a possible impact)?	No	
Does this activity deal with endangered fauna and/or flora / protected areas?	No	
Does this activity involve the use of substances or processes that may cause harm to humans, including those performing the activity (during the implementation of the activity or further to the use of the results, as a possible impact)?	No	
ARTIFICIAL INTELLIGENCE		
Does this activity involve the development, deployment and/or use of Artificial Intelligence?	No	
OTHER ETHICS ISSUES		
Are there any other ethical issues that should be taken into consideration?	No	

I CONFIRM that I have taken into account all ethics issues above. ☒

[3] Table assembled based on EC Horizon Europe Guidance: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/guidance/how-to-complete-your-ethics-self-assessment_en.pdf
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014R0536

7. CHECKLIST FOR PROPOSERS

The proposal conforms to the call guidelines.	☒
Every project partner has been in direct contact with his/her national / regional funding agency and has checked that their collaboration and their project contributions are eligible for funding.	☒
All project partners have checked the national/regional programme procedures and regulations. All project partners are aware of documents requested by the national/regional funding organisations. ***IMPORTANT REMINDER: All consortium partners must check if applications (at Pre-Proposal and/or Full-Proposal stage) have to be submitted also to their national/regional funding organisations.***	☒
All partners who are not eligible for 100% funding are able to provide financial resources for their own contribution.	☒
The consortium is aware that a duly signed and stamped consortium agreement (CA) between the project partners is recommended for funded projects based on national/regional funding rules, including agreements on intellectual property rights (IPR) and agreements on scientific publications. At the time of proposal submission it is recommended to provide the principles ruling the CA but not the CA itself.	☒

M-ERA.NET Call 2023

Annex 1 to the Full-Proposal: Partner Profiles and CVs (and LoIs, if relevant)

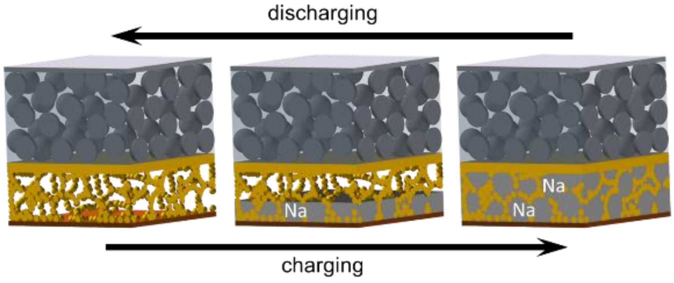
Project Acronym: Na-CerAnode

Project Coordinator:

(Organisation and Country):

Fraunhofer IKTS

Germany



8. Profiles of consortium members

Partner 1 (Coordinator): IKTS

Fraunhofer IKTS (Institute for Ceramic Technologies and Systems) is a part of the Fraunhofer society which is Europeans biggest organization for application near research having about 24500 employees. The Fraunhofer IKTS conducts applied research on high-performance ceramics (material synthesis & characterization, powder forming, granulate production). The institute‘s three sites in Dresden (Saxony) and Hermsdorf (Thuringia), Germany, collectively represent Europe‘s largest R&D institute dedicated to the study of ceramics. Fraunhofer IKTS has a strong background in the field of energy storage technology. This includes the processing of battery materials and the manufacturing of components for conventional as well as next generation solid-state batteries. Dedicated laboratories are equipped with powder processing equipment, tape casting equipment, a broad spectrum of sintering ovens, gloveboxes for the handling of battery materials and cell assembly. Some gloveboxes are dedicated for the handling of sulfidic battery materials. Furthermore, a fully equipped dry room (dew point -70°C) for electrode and cell manufacturing is available. A variety of methods is conducted for characterization of the electrode structure, electrochemical behaviour, and aging during battery operation. In the past years several public funded projects as well as bilateral industry projects have been performed in the field of liquid electrolyte and all-solid-state battery technology.

Role in the project:

Fraunhofer IKTS will coordinate the project. Furthermore, powders and tape casting processes will be developed for porous host structures and the obtained materials are characterized. IKTS will also test the best developed anodes in a full cell with commercial cathode. Finally, a sustainability assessment will be performed, and recycling strategies will be developed.

Team qualification in the field of proposal:

Three IKTS working groups participate in the project. The group *Cell and Process Development* headed by **Dr.-Ing. Kristian Nikolowski** deals with battery material evaluation and processing, component design and manufacturing, as well as battery characterization of in house build coin and pouch cells, and commercial cells. The group is thereby strongly engaged in post-lithium-ion technology e.g., sodium based and solid-state batteries. The group *Materials and components* headed by **Dr.-Ing. Jochen Schilm** is engaged in research and development of glasses, glass ceramics and ceramics for different applications such as solid electrolytes, electrodes, sealing materials functional coating for cathode materials, covering various routes of material synthesis, powder preparation and sintering strategies. The third group *Recycling & Green Battery* headed by **Dr. Sandra Pavon** will take over the sustainability and recyclability activities with it's expertise in developing recycling processes for the critical raw material recovery by including life cycle assessments.

CV's of Key Persons involved in the activities of the project

1st Key Person

<table>
<tr><td>First Name:</td><td colspan="2">Kristian</td><td colspan="2">Surname:</td><td>Nikolowski</td></tr>
<tr><td>Title:</td><td>Dr.-Ing.</td><td>E-mail[1]:</td><td colspan="3">kristian.nikolowski@ikts.fraunhofer.de</td></tr>
<tr><td>Phone[2]:</td><td colspan="2">+49 351 2553-7267</td><td colspan="2">Fax:</td><td>+49 351 2554-103</td></tr>
<tr><td>Organisational web page of key person[3]:</td><td colspan="5">https://www.ikts.fraunhofer.de/en.html</td></tr>
<tr><td>Personal web page[4]:</td><td colspan="5">https://www.ikts.fraunhofer.de/en/departments/energy_systems/mobile_energy_storage_systems_electrochemistry/cell_and_process_development.html</td></tr>
</table>

A. Relevant activities:

Relevant activities in the field of thematic area:

Kristian Nikolowski (male) studied Material Science at the University of Darmstadt (Germany). Afterwards he graduated with a PhD-thesis about structural analysis of cathode materials in lithium-ion-batteries in 2007. Followed by his employment as postdoc at IFW Dresden he worked as a research project manager for lithium-ion-batteries at HOPPECKE Advanced Battery Technology GmbH in an industrial environment. To continue his scientific career he moved to Karlsruhe, where he worked as group leader at the renowned Karlsruher Institute for Technology (KIT) in the research field of energy storage systems until 2013. Afterwards he moved

[1] *Organisational e-mail ...@<partner1>*
[2] *International format*
[3] *Official web page of key person in the organisation*
[4] *Personal web page, if applicable*

back to Dresden to join the group "mobile energy storage "at the Fraunhofer institute for ceramic technologies and systems (IKTS), where since 2017 he is group leader of the research group "cell concepts ". As mentioned, Kristian has gained experience on the subject of lithium-ion-batteries for more than 15 years, is author or co-author of more than 40 publications, h-index 24 (scopus) and is strongly committed to research in the field of energy storage technology.

Relevant activities in the field of the project:

Kristian has led and performed several projects in the field of material and processes for battery manufacturing, solid state batteries, sodium-based (solid-state) batteries and the electrical characterisation of energy storage devices. He is responsible for the working group “cell and process development” at Fraunhofer IKTS.

B. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1. Yanev, S.; Auer, H.; Heubner, C.; Höhn, S.; Nikolowski, K.; Partsch, M.; Michaelis, A. Rapid Determination of All-Solid-State Battery Performance via Chronoamperometry. J. Electrochem. Soc. 2022, 169 (9), 90519. DOI: 10.1149/1945-7111/ac8fbb.
2. Heubner, C.; Maletti, S.; Auer, H.; Hüttl, J.; Voigt, K.; Lohrberg, O.; Nikolowski, K.; Partsch, M.; Michaelis, A. From Lithium-Metal toward Anode-Free Solid-State Batteries: Current Developments, Issues, and Challenges. Adv. Funct. Mater. 2021, 2106608. DOI: 10.1002/adfm.202106608.
3. Hüttl, J.; Cai, W.; Wagner, D.; Schilm, J.; Kusnezoff, M.; Nikolowski, K.; Shaji, N.; Lee, C. W.; Partsch, M.; Michaelis, A. Polarization impedance at the Na-Na5YSi4O12 interface. Solid State Ionics 2022, 376, 115856. DOI: 10.1016/j.ssi.2022.115856.
4. Heubner, C.; Voigt, K.; Marcinkowski, P.; Reuber, S.; Nikolowski, K.; Schneider, M.; Partsch, M.; Michaelis, A. From Active Materials to Battery Cells: A Straightforward Tool to Determine Performance Metrics and Support Developments at an Application-Relevant Level. Adv. Energy Mater. 2021, 11 (46), 2102647. DOI: 10.1002/aenm.202102647.
5. Schreiber, A.; Rosen, M.; Waetzig, K.; Nikolowski, K.; Schiffmann, N.; Wiggers, H.; Küpers, M.; Fattakhova-Rohlfing, D.; Kuckshinrichs, W.; Guillon, O.; Finsterbusch, M. Oxide ceramic electrolytes for all-solid-state lithium batteries – cost-cutting cell design and environmental impact. Green Chem. 2023, 25 (1), 399–414. DOI: 10.1039/D2GC03368B.

Relevant projects in the field of thematic area (*maximum 5*):

1. S3B - Materials and Interface Design for Sodium Solid State Battery, 2021-2024. (BMBF, Grant No. 01DR21008A)
2. HeNa – Manufacturing technology for Sodium Solid State Batteries, 2021 – 2024. (BMBF, Grant No. 03XP0390A)
3. ASTRABAT - All Solid-sTate Reliable BATtery for 2025, 2020 - 2023. (EU, Grant No 875029)
4. ReCycle - Automation as a key technology for the economic remanufacturing of lithium-ion battery systems, 2021 - 2022. (BMWi Grant No. 03ETE031K)
5. ReDesign - Development of design guidelines for the recycling-friendly design of battery systems in the context of the circular economy, 2020 - 2023. (BMBF Grant No 03XP0318B)

Relevant applied activities (for companies e.g. product, processes, etc.):

Worked for the company HOPPECKE in the past, where he was involved in the development of lithium and hybrid energy storage systems for industrial applications. At HOPPECKE he was research project manager and responsible for internal and external research and development projects. Furthermore, Kristian is co-inventor in the following patents:

1. Freytag, C.; Kusnezoff, M.; **Nikolowski, K**.; Partsch, U.; Schilm, J.; Wolter, M.; Tag, C. (2019): PROCESS FOR PRODUCING AN ELECTROCHEMICAL CELL, AND ELECTROCHEMICAL CELL PRODUCED BY THE PROCESS. FRAUNHOFER GES. US2019157724A.
2. Kusnezoff, M.; **Nikolowski, K**.; Schilm, J.; Wolter, M. (2019): COMPOSITE CATHODE LAYERED STRUCTURE FOR SOLID STATE BATTERIES ON A LITHIUM BASIS AND A METHOD FOR MANUFACTURING SAME. FRAUNHOFER GES. US2019157670A.
3. Wolter, Mareike; Seidel, Matthias; **Nikolowski, K.**; Leidolph, Lars; Jaehnert, Thomas; Jacob, Michael; Boeber, Reinhard (2019): METHOD FOR PRODUCING MIXED OXIDE POWDERS, AND A MIXED OXIDE POWDER. FRAUNHOFER GES FORSCHUNG; GLATT INGTECH GMBH. WO19197147A1.
4. Clauss, Michael; Echelmeyer, T.; **Nikolowski, K**.; Partsch, U.; Roscher, M.; Tittel, D.; Wolter, Mareike (2018): ELECTRICAL ENERGY STORAGE ELEMENT, METHOD AND APPARATUS FOR PRODUCING SAID ELECTRICAL ENERGY STORAGE ELEMENT. FRAUNHOFER GES; THYSSENKRUPP SYSTEM ENGINEERING GMBH; IAV GMBH. US2018034107A.

2nd Key Person

First Name:	Dörte		**Surname:**	Wagner
Title:	Dr.-Ing.	**E-mail[5]:**	Doerte.wagner@ikts.fraunhofer.de	
Phone [6]:	+49 351 2553-7335		**Fax:**	
Organizational web page of key person [7]:	https://www.ikts.fraunhofer.de/en.html			
Personal web page[8]:	https://www.ikts.fraunhofer.de/de/abteilungen/energiesysteme/werkstoffe_komponenten/fuegetechnik_avt.html			

A. Relevant activities:

Relevant activities in the field of thematic area: **Dörte Wagner** (female) studied Material Science at the TU Bergakademie Freiberg in Saxony. Afterwards she worked for Brandenburgische Kondensatoren building and investigating Supercaps in Prenzlau. Since 2012 she is working as scientist at Fraunhofer IKTS working on lithium ion and sodium solid electrolytes for battery applications including the synthesis of the material, shaping technologies and the optimization of the sintering process. Further fields of her research are SOFC glass seals and glasses for additive manufacturing. She graduated her PhD in 2022 investigating sodium conducting glass ceramics as solid electrolytes for room temperature sodium batteries.

Dörte is working on sodium battery electrolytes for 8 years now, participating in various national and international projects, presenting results on international conferences. She is author or co-author of at least 15 publications on sodium electrolytes.

Relevant activities in the field of the project: In the research field of solid sodium electrolytes, she gained expertise in synthesis of conducting glass ceramics, designing their properties and different shaping technologies, such as tape casting of thin glass ceramic layers.

B. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

[5] *Organisational e-mail ...@<partner1>*
[6] *International format*
[7] *Official web page of key person in the organisation*
[8] *Personal web page, if applicable*

Dörte Wagner, Jochen Schilm, Chang Woo Lee, Mihails Kusnezoff, Impact of precrystallized NaYSi2O12 powders in the synthesis of sodium conducting solid electrolytes (2020), Energy Technology 2020, 8, 2000559, DOI 10.1002/ente.20200559

J.Schilm, D.Wagner, C.Heubner, U.Langklotz, C.W.Lee, H.S.Kang, J.W.Park, M.Kusnezoff ,Sintering of sodium conducting glass ceramics in the Na_2O-Y_2O_3-SiO_2-system, (2021), Journal of the European Ceramic Society, Volume 41, Issue 9, August 2021, Pages 4876-4883,

Mihails Kusnezoff, Dörte Wagner, Jochen Schilm, Christian Heubner, Björn Matthey; Microstructure and crystalline phases influence on impedance spectra of sodium conducting glass ceramics produced from glass powder (2021), Journal of Solid State Electrochemistry, https://doi.org/10.1007/s10008-021-05063-0

Dörte Wagner, Mihails Kusnezoff, Jochen Schilm, Christian Heubner, Mathias Herrmann, Andre Weber, Philipp Braun, Chang Woo Lee, Nitheesha Shaji (2022), High frequency impedance measurements of sodium solid electrolytes, Journal of the European Ceramic Society https://doi.org/10.1016/j.jeurceramsoc.2022.03.023

Jochen Schilm, Rafael Anton , Dörte Wagner , Juliane Huettl , Mihails Kusnezoff , Mathias Herrmann, Hong Ki Kim and Chang Woo Lee (2022), Influence of R=Y, Gd, Sm on Crystallization and Sodium Ion Conductivity of Na5RSi4O12 Phase, Materials; https://doi.org/10.3390/ma15031104

Relevant projects in the field of thematic area (*maximum 5*):

BaSta- Batterie stationär in Sachsen, 0325563A

BaMoSa- Batterie - mobil in Sachsen,03X4637

Artemys- SkAlieRbare, kostengünstige FertigungsTEchnologien für KoMpositkathoden und ElektrolYtseparatoren in FeStkörperbatterien, 03XP0114I

HeNa- Herstellungswege für Natrium-Festkörperbatterien 03XP0390A/C/D und 13XP0390B

S3B- Materials and Interface Design for Sodium Solid State Battery, 2021-2024. (BMBF, Grant No. 01DR21008A)

Relevant applied activities (for companies e.g. product, processes, etc.): Dörte is co-inventor of the following patent:

PCT/EP2016/055132; DE102015204465B4 Jochen Schilm, Mihails Kusnezoff, **Dörte Wagner**, Axel Rost; NATRIUMIONENLEITENDES ELEMENT FÜR DIE ANWENDUNG IN ELEKTROCHEMISCHEN ZELLNE SOWIE EIN VERFAHREN ZU DESSEN HERSTELLUNG

3rd Key Person

First Name:	Nicolas		**Surname:**	Zapp
Title:	Dr.	**E-mail[9]:**	nicolas.zapp@ikts.fraunhofer.de	
Phone[10]:	+49 351 2553 7682		**Fax:**	+49 351 2554-103
Organizational web page of key person[11]:	https://www.ikts.fraunhofer.de/en.html			
Personal web page[12]:	https://www.ikts.fraunhofer.de/en/departments/energy_systems/mobile_energy_storage_systems_electrochemistry/cell_and_process_development.html			

A. Relevant activities:

Relevant activities in the field of thematic area:

Nicolas Zapp (male) studied chemistry at Saarland University (Germany) and subsequently performed his PhD studies in Leipzig (Germany) on solid-state chemistry of hydride-ion conductors. After his graduation in 2021, he worked as a postdoc scientist at Fraunhofer IKTS in Dresden where he currently works on different national and international projects on solid state batteries.

Relevant activities in the field of the project:

Nicolas has performed several projects in the field of electrochemical characterisation of batteries. He has expertise in manufacture of solid-state and conventional lithium-ion batteries as well as the electrochemical characterization of batteries and their materials by e.g. electrochemical impedance spectroscopy or cycling experiments.

B. Scientific activities

Relevant publications in the field of thematic area (*maximum 5*):

1. J. Hüttl, N. Zapp, S. Tanikawa, K. Nikolowski, A. Michaelis, H. Auer, A Layered Hybrid Oxide-Sulfide All-Solid-State Battery with Lithium Metal Anode, **Batteries** 2023, *9*, 507.

[9] *Organisational e-mail ...@<partner1>*
[10] *International format*
[11] *Official web page of key person in the organisation*
[12] *Personal web page, if applicable*

2. J. P. Beaupain, K. Waetzig, H. Auer, N. Zapp, K. Nikolowski, M. Partsch, M. Kusnezoff, A. Michaelis, Co-Sintering of $Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$ and $LiFePO_4$ in Tape-Casted Composite Cathodes for Oxide Solid-State Batteries, *Batteries* **2023**, *9*, 543.

Relevant projects in the field of thematic area (*maximum 5*):

1. OPERA – Development of OPERAndo Techniques and Multiscale Modelling to face the Zero-Excess Solid-State Battery Challenge, 2023-2026 (EU, Grant No. 101103834)
2. ASTRABAT - All Solid-sTate Reliable BATtery for 2025, 2020 - 2023. (EU, Grant No 875029)
3. FestBatt – Development and scaling of oxide-based solid electrolytes, co-sintering of cathodes, development of oxide-based cell concepts (BMBF Grant No. 03XP434B)

4th Key Person

First Name:	Sandra		**Surname:**	Pavón
Title:	Dr.-Eng	**E-mail[13]:**	sandra.pavon.regana@ikts.fraunhofer.de	
Phone[14]:	**+49 3731 2033-169**		**Fax:**	
Organizational web page of key person[15]:	http: https://www.ikts.fraunhofer.de/en/departments/energy_systems/mobile_energy_storage_systems_electrochemistry/recycling_green_battery.html			
Personal web page[16]:	http:			

C. Relevant activities:

Relevant activities in the field of thematic area: Dr. Sandra Pavón is a chemical engineer and holds a PhD in chemical process engineering since 2019 from the Polytechnic University of Catalonia. The research area where she is an expert is in the recovery of critical raw materials such as lithium, rare earths, cobalt, nickel. She did a post-doc at the Freiberg University of Mining and Technology in Germany (2019-2022) focusing on the development of holistic processes for the recovery of critical and strategic metals from both primary and secondary sources. Since 2022 she is working as group leader of the recycling and green battery group at the Fraunhofer IKTS

[13] *Organisational e-mail ...@<partner1>*
[14] *International format*
[15] *Official web page of key person in the organisation*
[16] *Personal web page, if applicable*

research center focusing on the development and validation of recycling processes in higher TRL. During her professional career, she has published more than 30 scientific publications in peer-reviewed journals and 2 book's chapters and presented numerous talks at international conferences.

Relevant activities in the field of the project:

- Process development for critical raw material recovery
- Evaluation of recycling processes by sustainable assessments
- Validation of recycling processes (scale-up)

D. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

(1) M. Bertau, P. Fröhlich, S. Pavón (2023) 6.1 Resources: minerals, recycling and urban mining; Energy Storage to Photofunctional Materials, DOI: 10.1515/9783110798890-009

(2) S. Pavón, A. Nickol, S. Hippmann, M. Partsch, A. Michaelis: The COOL-Process – a holistic recycling approach for lithium recovery. 2nd International Conference on Raw Materials and Circular Economy. Athens, Greece. 28 AUG-02 SEP 2023

(3) S. Pavón, M. Kah, S. Hippmann, M. Bertau (2022) Lithium recovery from production waste by thermal pre-treat-ment, Sustainable Chemistry and Pharmacy, 28, S. 100725. DOI: 10.1016/j.scp.2022.100725

(4) S. Pavón, D. Kaiser, M. Bertau (2021) Recovery of Al, Co, Cu, Fe, Mn, and Ni from spent LIBs after Li selective separation by COOL-Process – Part 2: Solvent Extraction from Sulphate Leaching Solution. Chemie Ingenieur Technik 93, 11, 1840-1850, DOI:10.1002/cite.202100101

(5) S. Pavón, D. Kaiser, R. Mende, M. Bertau (2021) The COOL-Process - a selective approach for recycling lithium batteries. Metals 11, 259, DOI: 10.3390/met11020259. Selectively lithium recovery by digestion with CO2 obtaining Li2CO3 in battery grade as a product.

Relevant projects in the field of thematic area (*maximum 5*):

(1) METALLICO (Horizon Europe; GA: 101091682). Dealing with the recovery of battery metals from primary and secondary resources through a sustainable processing methodology. METALLICO includes 4 cases studies in the EU to recover CRM such as Li, Co, Ni.

(2) MoLIBity (FFG Forschung wirkt.). Development of recycling process for Li-ion-Batteries to recover the critical raw materials such as Li, Co, Ni, Mn through hydrometallurgical processes.

(3) EVanBatter (Federal Ministry of Education and Research). Robust resynthesis processes (TRL 5-6) are being developed that enable both cathode and anode materials to be returned to the process cycle of electrode production.

(4) EarLiMet (Federal Ministry of Education and Research). Developing a holistic, resource efficient, hydrometallurgy-based recycling of valuables in Li-ion batteries up to TRL 5/6. After selective recovery of Li, the separation of Mn, Co, Ni is carried out by combination of electrochemical processes and solvent extraction.

(5) ReDesign (Federal Ministry of Education and Research). Dealing with the aspects of a recycling-friendly design of Li-ion cells. Based on a design analysis of various cells, material-specific and constructive concepts are being developed to improve the recycling efficiency of future EoL batteries. Regulatory policy considerations are considered and implemented in sustainability assessments.

Relevant applied activities (for companies e.g. product, processes, etc.):

Partner 2: CEMEA

Role in the project:

The CEMEA team will be responsible for fabricating and optimizing ALD layers in porous anode structures. Furthermore, the CEMEA team will be responsible for applying *operando* top-view microscopy of Na nucleation and growth and *operando* X-ray diffraction during galvanostatic charging/discharging.

Team qualification in the field of proposal:

The research group of **Dr. Peter Siffalovic** is specialized in the application of synchrotron and laboratory X-ray sources for various time-resolved and in-situ studies of nanomaterials. The CEMEA SAS laboratories have all the equipment required to carry this project, such as standard and high-brilliance X-ray sources. Additional equipment is available for the analysis of nanomaterials in direct space, including AFM, CRM, nano-FTIR, SEM, etc.

Dr. Karol Fröhlich's research group at CEMEA is dedicated to advanced deposition and analysis of thin films using ALD. His research laboratory has all the necessary techniques to analyze and apply ALD thin films in Li-ion batteries.

CV's of Key Persons involved in the activities of the project

1st Key Person

First Name:	Peter	**Surname:**	Siffalovic
Title:	Dr.	**E-mail[17]:**	peter.siffalovic@savba.sk
Phone[18]:	+421 949 556 037	**Fax:**	
Organisational web page of key person [19]:	http: https://cemea.sav.sk/en/		
Personal web page[20]:	http: https://scholar.google.com/citations?user=_-KOEeQAAAAJ&hl=sk		

A. Relevant activities:

Education:

1998 M.Sc. Physics, Comenius University, Bratislava, Slovakia and Shizuoka University, Hamamatsu, Japan

2002 Dr. Rer. Nat. (*summa cum laude*) in Physics, Universität Bielefeld, Bielefeld, Germany

[17] *Organisational e-mail ...@<partner1>*
[18] *International format*
[19] *Official web page of key person in the organisation*
[20] *Personal web page, if applicable*

2021 DrSc. (equivalent of DSc., research professor), Slovak Academy of Sciences, Bratislava, Slovakia

Current position:

Research Professor, CEMEA, Slovak Academy of Sciences, Slovakia.

Publications: 176, Citations: 2.035 (according to Scopus database)

Relevant activities in the field of thematic area:

He is expert of application of in-situ X-ray scattering (SAXS/WAXS) to self-assembly and crystallization of nanomaterials in real-time. Furthermore, his expertise covers correlation of *in-situ* time-resolved reciprocal space measurements with *ex-situ* direct space measurement including AFM, SEM, UV-VIS spectroscopy, photoluminescence, etc.

Relevant activities in the field of the project:

He will be responsible for the advanced development of an *operando* solid-state battery cell for X-ray scattering. He will also be responsible for SAXS/WAXS laboratory measurements in combination with GCD/CV techniques.

B. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1. Ashraf, M. A., Vegso, K., Shaji, A., Bodik, M., Sánchez, M. G., Zubair, M., Din, M. F. U., Majkova, E., Fedorková, A. S., Keckes, J., & **Siffalovic, P.** (2022). Aligned Bilayer of Single-Walled Carbon Nanotubes Suppresses the Polysulfide Shuttle in Li-S Batteries. *ACS Applied Energy Materials*, *5*(12), 15649–15655.
2. De Bastiani, M., Jalmood, R., Liu, J., Ossig, C., Vlk, A., Vegso, K., Babics, M., Isikgor, F. H., Selvin, A. S., Azmi, R., Ugur, E., Banerjee, S., Mirabelli, A. J., Aydin, E., Allen, T. G., Ur Rehman, A., Van Kerschaver, E., **Siffalovic, P.**, Stuckelberger, M. E., … De Wolf, S. (2022). Monolithic Perovskite/Silicon Tandems with >28% Efficiency: Role of Silicon-Surface Texture on Perovskite Properties. *Advanced Functional Materials*, 2205557.
3. Held, V., Mrkyvkova, N., Nádaždy, P., Vegso, K., Vlk, A., Ledinský, M., Jergel, M., Chumakov, A., Roth, S. V., Schreiber, F., & **Siffalovic, P.** (2022). Evolution of Structure and Optoelectronic Properties during Halide Perovskite Vapor Deposition. *Journal of Physical Chemistry Letters*, 11905–11912.
4. Kovaricek, P., Nadazdy, P., Pluharova, E., Brunova, A., Subair, R., Vegso, K., Guerra, V. L. P., Volochanskyi, O., Kalbac, M., Krasnansky, A., Pandit, P., Roth, S. V., Hinderhofer, A., Majkova, E., Jergel, M., Tian, J., Schreiber, F., & **Siffalovic, P.** (2021). Crystallization of 2D Hybrid Organic–Inorganic Perovskites Templated by Conductive Substrates. *Advanced Functional Materials*, *31*(13), 2009007.

5. Lu, B., Vegso, K., Micky, S., Ritz, C., Bodik, M., Fedoryshyn, Y. M., **Siffalovic, P.**, & Stemmer, A. (2023). Tunable Subnanometer Gaps in Self-Assembled Monolayer Gold Nanoparticle Superlattices Enabling Strong Plasmonic Field Confinement. *ACS Nano*, *17*, 12774–12787.

Relevant projects in the field of thematic area (*maximum 5*):

1. OPERA, HORIZON-RIA / EU, 2023 - 2026, PI in SK
2. SEATBELT, HORIZON-RIA / EU, 2023 - 2026, PI in SK
3. BATAX, APVV / SK, 2021 - 2025, PI
4. SOLIMEC, M-ERA.NET / EU, 2022 - 2025, PI in SK
5. MIT-Slovakia Seed Fund, MISTI / MIT, USA, 30,000, 2022 - 2024, PI

Relevant applied activities (for companies e.g. product, processes, etc.):

1. Research and development of channel monochromators based on Ge single crystals for the company Integra TDS s.r.o.

2. Research, development, and realization of multilayer mirrors for Free-electron Laser in Hamburg (Germany) and intensive cooperation with Incoatec GmbH, Geesthacht (Germany)

3. Development, realization, and sales of scatter-free slits for X-ray radiation for Rigaku Ltd. (USA), Anton Paar (Austria), Synchrotron in Hsinchu (Taiwan), University of Leoben and University of Vienna (Austria)

2nd Key Person

<table>
<tr><td>First Name:</td><td colspan="2">Karol</td><td>Surname:</td><td>Frohlich</td></tr>
<tr><td>Title:</td><td>Dr.</td><td>E-mail[21]:</td><td colspan="2">karol.frohlich@savba.sk</td></tr>
<tr><td>Phone[22]:</td><td colspan="2">+421 903 793 724</td><td>Fax:</td><td></td></tr>
<tr><td>Organizational web page of key person [23]:</td><td colspan="4">http: https://cemea.sav.sk/en/</td></tr>
<tr><td>Personal web page[24]:</td><td colspan="4">http: https://scholar.google.com/citations?hl=sk&user=z5wBvOcAAAAJ</td></tr>
</table>

[21] *Organisational e-mail ...@<partner1>*
[22] *International format*
[23] *Official web page of key person in the organisation*
[24] *Personal web page, if applicable*

A. Relevant activities:

1977 Ing. Degree, Slovak University of Technology, Faculty of Electrical Engineering, Bratislava

2002 PhD., Slovak University of Technology, Faculty of Electrical Engineering, Bratislava

2012 DrSc. (equivalent of DSc., research professor), Institute of Electrical Engineering, Slovak Academy of Sciences, Bratislava

Current position:

Research Professor, CEMEA, Slovak Academy of Sciences, Slovakia.

Publications: 184, Citations: 2.089 (according to Scopus database)

Relevant activities in the field of thematic area:

Recognized expert in the field of fabrication and characterization of ALD coatings for electronic applications. In-depth understanding of ALD coatings for the stabilization of cathode and anode materials in Li-ion batteries.

Relevant activities in the field of the project:

He will be responsible for coordinating the preparation of ALD layers for Na solid-state batteries.

B. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1. Kundrata, I., Barr, M.K.S., Tymek, S., Döhler, D., Hudec, B., Brüner, P., Vanko, G., Precner, M., Yokosawa, T., Spiecker, E., Plakhotnyuk, M., **Fröhlich**, K., and Bachmann, J.: Small Methods (2022) 2101546.
2. Kundrata, I., Mošková, A., Moško, M., Mičušík, M., Dobročka, E., and **Fröhlich**, K.: J. Vacuum Sci Technol. A 39 (2021) 062407.
3. Sahoo, P.P., Mikolášek, M., Hušeková, K., Dobročka, E., Šoltýs, J., Ondrejka, P., Kemény, M., Harmatha, L., Mičušík, M., and **Fröhlich**, K.: ACS Applied Energy Mater. 4 (2021) 11162-11172.
4. Mošková, A., Moško, M., Precner, M., Mikolášek, M., Rosová, A., Mičušík, M., Štrbík, V., Šoltýs, J., Gucmann, F., Dobročka, E., and **Fröhlich**, K.: J. Applied Phys. 130 (2021) 035106.
5. Niu, G., Calka, P., Huang, P., Sharath, S.U., Petzold, S., Gloskovskii, A., **Fröhlich**, K., Zhao, Y., Kang, J., Schubert, M.A., Bärwolf, F., Ren, W., Ye, Z.-G., Perez, E., Wenger, C., Alff, L., and Schroeder, T., Mater. Res. Lett. 7 (2019) 117-123.

Relevant projects in the field of thematic area (*maximum 5*):

1. The atomic-layer 3D plotter, **H2020** project No. 950785, 2020-2022,PI for SK.
2. Towards lithium-based batteries with improved lifetime. APVV-20-0111, 2021-2025, participant
3. Carbon-silicon based composite anodes for Li-ion batteries. APVV-19-0461, 2020-2024, PI
4. Resistive switching structures for pattern recognition, APVV-14-0560, 2015-2018, PI

5. Metal-oxide-metal structures for resistive switching-based nanoscale memory, APVV-0509-10, 2011-2014, PI

Relevant applied activities (for companies e.g. product, processes, etc.):

3rd Key Person

First Name:	Nada		**Surname:**	Mrkyvkova
Title:	Dr.	**E-mail[25]:**	nada.mrkyvkova@savba.sk	
Phone[26]:	+421 903 410 091		**Fax:**	
Organizational web page of key person [27]:	http: https://cemea.sav.sk/en/			
Personal web page[28]:	http: https://scholar.google.com/citations?hl=en&user=kyCnT0QAAAAJ			

A. Relevant activities:

2008 MSc. In Physics, Faculty of Mathematics and Physics, Charles University, Czechia

2013 PhD., Faculty of Mathematics and Physics, Charles University, Czechia

Current position:

Independent Researcher, CEMEA, Slovak Academy of Sciences, Slovakia.

Publications: 35, Citations: 625 (according to Scopus database)

Relevant activities in the field of thematic area:

Recognized expert in the application of real-time X-ray scattering and spectroscopic techniques.

Relevant activities in the field of the project:

She will be responsible for performing *operando* optical microscopy and Raman spectroscopy measurements during Na plating.

B. Scientific activities:

[25] *Organisational e-mail ...@<partner1>*
[26] *International format*
[27] *Official web page of key person in the organisation*
[28] *Personal web page, if applicable*

Relevant publications in the field of thematic area (*maximum 5*):

1. Held, V., **Mrkyvkova, N.**, Nádaždy, P., Vegso, K., Vlk, A., Ledinský, M., Jergel, M., Chumakov, A., Roth, S. V., Schreiber, F., & Siffalovic, P. (2022). Evolution of Structure and Optoelectronic Properties during Halide Perovskite Vapor Deposition. *Journal of Physical Chemistry Letters*, 11905–11912.
2. **Mrkyvkova, N.**, Held, V., Halahovets, Y., Nádaždy, P., Jergel, M., Majková, E., Schreiber, F., & Siffalovic, P. (2022). Simultaneous measurement of X-ray scattering and photoluminescence during molecular deposition. *Journal of Luminescence*, *248*, 118950.
3. **Mrkyvkova, N.**, Held, V., Nádaždy, P., Subair, R., Majkova, E., Jergel, M., Vlk, A., Ledinsky, M., Kotlár, M., Tian, J., & Siffalovic, P. (2021). Combined in Situ Photoluminescence and X-ray Scattering Reveals Defect Formation in Lead-Halide Perovskite Films . *The Journal of Physical Chemistry Letters*, *12*(41), 10156–10162.
4. Wang, T., Zheng, D., Vegso, K., **Mrkyvkova, N.**, Siffalovic, P., & Pauporté, T. (2023). High-Resolution and Stable Ruddlesden–Popper Quasi-2D Perovskite Flexible Photodetectors Arrays for Potential Applications as Optical Image Sensor. *Advanced Functional Materials*, *33*(43), 2304659.
5. Wang, T., Zheng, D., Vegso, K., **Mrkyvkova, N.**, Siffalovic, P., Yuan, X., Somekh, M. G., Coolen, L., Pauporte, T., & Fu, F. (2023). Flexible array of high performance and stable formamidinium-based low-n 2D halide perovskite photodetectors for optical imaging. *Nano Energy*, *116*, 108827.

Relevant projects in the field of thematic area (*maximum 5*):

1. Towards Superior Perovskite-based Solar Cells via Optimized Passivation and Structure, APVV project, 2022-2026, PI
2. Perovskite-based Films with Superior Passivation and Structure, APVV project, 2022-2025, participant
3. Molecular nanostructures on two-dimensional substrates, APVV, 2021-2023, PI
4. Perovskites Quantum Dots based Broadband Detectors – from a quantum dot to a functional detector, V4-Japan, 2021-2024, participant
5. Beyond 27% perovksite solar cells: A deep study based on in-situ charge dynamics and crystal growth kinetics, V4-Korea, 2023-2026, PI

Relevant applied activities (for companies e.g. product, processes, etc.):

4th Key Person

First Name:	Prangya		**Surname:**	Sahoo
Title:	Dr.	**E-mail[29]:**	prangya.sahoo@savba.sk	
Phone[30]:	+47 973 71 356		**Fax:**	
Organizational web page of key person [31]:	http: https://cemea.sav.sk/en/			
Personal web page[32]:	http: https://scholar.google.com/citations?hl=sk&user=Gf2jwUYAAAAJ			

A. Relevant activities:

2005 MSc., Utkal University, Deptartment of Chemistry, Bhubaneswar

2011 PhD., Indian Institute of Science, Bangalore, India

Current position:

Independent Researcher, CEMEA, Slovak Academy of Sciences, Slovakia.

Publications: 16, Citations: 408 (according to Scopus database)

Relevant activities in the field of thematic area:

Recognized expert in the application of advanced electrochemical methods to energy-related materials.

Relevant activities in the field of the project:

She will be responsible for the assembly of operando cells and the application of ALD coatings on various porous structures.

B. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1) **Sahoo, P.P.**, Mikolášek, M., Hušeková, K., Dobročka, E., Šoltýs, J., Ondrejka, P., Kemény, M., Harmatha, L., Mičušík, M., and Fröhlich, K.: *ACS Applied Energy Mater.* 4 (2021) 11162-11172.
2) Cendula, P., **Sahoo, P.P.**, Cibira, G. and Simon, P. : *J. Phys. Chem. C*, 124 (2020) 1269-1276.
3) **Sahoo, P.P.**, Zoellner, B., and Maggard, P.A. : *J. Mater. Chem. A* 3 (2015) 4501-4509.

[29] *Organisational e-mail ...@<partner1>*
[30] *International format*
[31] *Official web page of key person in the organisation*
[32] *Personal web page, if applicable*

4) **Sahoo, P.P.**, Payne, J.P., Li, M., Claridge, J.B., and Rosseinsky, M.J. : *J. Phys. Chem. Sol.* 76 (2015) 82-87.
5) King, N., **Sahoo, P.P.**, Fuoco, L., Stuart, S., Dougherty, D., Liu, Y., and Maggard, P.A. : *Chem. Mater.*, 26 (2014) 2095-2104.

Relevant projects in the field of thematic area (*maximum 5*):

1) Towards lithium-based batteries with improved lifetime. APVV, 2021-2025, participant
2) Carbon-silicon based composite anodes for Li-ion batteries, APVV, 2020-2024, researcher
3) Nanotechnology preparation of a MIC photoelectrode with metallic oxides for systems for production of solar fuels, APVV, 2017-2021, participant
4) EU-Project SIMBA (Sodium-Ion and Sodium-Metal Batteries for efficient and sustainable next-generation energy storage, Grant Number: 963542, participant
5) Low energy synthesis route for the production of NaSICON-like structured cathodes for rechargeable Sodium-Ion Batteries (SIBs), VEGA, participant

Relevant applied activities (for companies e.g. product, processes, etc.):

Partner 3: LaMaV

Role in the project:

LaMaV will apply the newly developed and energy-efficient Flash-sinter-crystallization to obtain glass-ceramics solid electrolytes. Also, this method will be used to sinter tapes obtained by tape casting. These co-sintered tapes will act as the Na-CerAnode and possibly be joined with a Nasicon solid electrolyte.

Team qualification in the field of proposal:

The Vitreous Material Laboratory of the Federal University of São Carlos (LaMaV) has been dedicated for more than 40 years to investigating the peculiarities of glass and related materials like glass ceramics. LaMaV is the leading laboratory constituting the CeRTEV, Center for Research, Technology and Vitreous Materials, an 11-year Fapesp program (in English: Research, Innovation and Dissemination Centers (RIDCs) funded by Fapesp, the São Paulo State Funding Agency, partner at M-Era-Net. Beyond the search for new glasses and understanding of the glass-to-crystal transformation, one of the main topics on LaMaV´s agenda is the electrical properties of glass and glass ceramics. Indeed, LaMaV has been dedicated lately to developing new glass ceramics with Nasicon structure and sodium ion conductors to act as solid electrolytes in solid-state batteries. At least two submitted patents resulted from research in this field. LaMaV has all the facilities for melting and characterizing glass and glass ceramics. V is inserted in the Materials Engineering Department from UFSCar and counts on facilities like

LCE, the Laboratory for Structural Characterization. São Carlos, a well-known Industrial and Innovation Center in Brazil, has incubators of high-technology companies, and an enabling environment for materials research and development. All participants have experience in ceramic synthesis and/or electrical characterization.

CV's of Key Persons involved in the activities of the project

1st Key Person

First Name:	Ana Candida Martins	**Surname:**	Rodrigues
Title:	Prof. Dr.	**E-mail[33]:**	acmr@ufscar.br
Phone[34]:	+55 16 3351 8556	**Fax:**	
Organisational web page of key person [35]:	http: http://lamav.weebly.com/ https://www.dema.ufscar.br/en/home?set_language=en https://www.certev.ufscar.br/en		
Personal web page[36]:	https://www.ppgcem.ufscar.br/pt-br/docentes/ana-candida-martins-rodrigues		

C. Relevant activities:

Relevant activities in the field of thematic area:

Ana C. M. Rodrigues is a Full Professor at the Department of Materials Engineering from the Federal University of São Carlos, Brazil. Since her Ph.D., her main research topic has been glasses and glass-ceramics, especially electrical properties. She works with solid electrolytes for Li and Na batteries, especially glass ceramics with Nasicon structures. In an original and recent article, Prof. Rodrigues and her team developed "The flash-sinter-crystallization" to obtain glass-ceramics by electric field-assisted crystallization. Currently the Chair of the Technical Committee TC23 "Glass Education" of the International Commission of Glass, she is also the Coordinator of Education and Outreach of the Center for Research, Technology, and Education in Vitreous Materials (CeRTEV), an 11-year funded program by the Funding Agency from São Paulo State in Brazil, Fapesp

Relevant activities in the field of the project:

[33] *Organisational e-mail ...@<partner1>*
[34] *International format*
[35] *Official web page of key person in the organisation*
[36] *Personal web page, if applicable*

Prof. Rodrigues currently works to improve the synthesis of solid electrolytes for Na and Li Batteries, by applying electric field assisted synthesis to bulk glass or glass-pellets. Flash-sintering-crystallization is a new method (patent pending) developed in LaMaV to obtain glass ceramics. The method is energy efficient and allows a rapid synthesis of glass-ceramics.

D. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1. Campos, J.V., Lavagnini, I.R., Zallocco V.M., Jesus L.M., **Rodrigues, A.C.M.,** Ultrafast crystallization and sintering of Li1.3Al0.3Ti1.7(PO4)3 glass through flash sinter-crystallization. J Am Ceram Soc. 1–16, 2023, published on-line

2. CAMPOS, JOÃO V.; LAVAGNINI, ISABELA R.; ZALLOCCO, VINICIUS M.; FERREIRA, EDUARDO B.; Pallone, Eliria M.J.A.; **RODRIGUES, ANA C.M.** Flash sintering with concurrent crystallization of Li1.5Al0.5Ge1.5(PO4)3 glass. ACTA MATERIALIA, v. 244, p. 118593, 2023.

3. DIAS, JEFERSON A.; SANTAGNELI, SILVIA H.; **RODRIGUES, ANA C. M.**; BÔAS, NAIZA V.; MESSADDEQ, YOUNÈS. Understanding the Evolution of the Structure and Electrical Properties during Crystallization of $Li_{1.5}Al_{0.5}Ge_{1.5}(PO_4)_3$ and $Li_{1.5}Sc_{0.17}Al_{0.33}Ge_{1.5}(PO_4)_3$NASICON -Type Glass Ceramics. Journal of Physical Chemistry C, v. 127, p. 6207-6225, 2023.

4. ORTIZ-MOSQUERA, JAIRO F.; NIETO-MUÑOZ, ADRIANA M.; **RODRIGUES, ANA C.M.**, “Influence of Al3+ on glass-forming ability, structural and electrical properties of the Na3.4Sc2Si0.4P2.6O12 superionic conductor”, JOURNAL OF ALLOYS AND COMPOUNDS, v. 850, p. 156670, 2021.

5. ORTIZ-MOSQUERA, JAIRO F.; NIETO-MUÑOZ, ADRIANA M.; **RODRIGUES, ANA C. M.**, “New Na 1+ x Ge 2 (SiO 4) x (PO 4) 3- x NASICON Series with Improved Grain and Grain Boundary Conductivities”, ACS Applied Materials & Interfaces, v. 12, p. 13914-13922, 2020.

Relevant projects in the field of thematic area (*maximum 5*):

1. Ionic conductor glass-ceramics sintering with concurrent crystallization using flash sintering; duration: 08/2021 - 07/2024; Funding agency: FAPESP – Sao Paulo Research Foundation (Post-doctoral Grant no: 2021/06509-9) (supervisor).

2. Ultrafast sintering and crystallization with the application of an electric field in Li2O-Al2O3-SiO2 (LAS) glass system with antimicrobial properties; duration: 09/2023 – 08/2025; Funding agency: FAPESP – Sao Paulo Research Foundation (Post-docatoral Grant no: 2022/13532-0) (supervisor).

3. Ultra-rapid crystallization of dental glass ceramics assisted by electric field – submitted to Fapesp

Relevant applied activities (for companies e.g. product, processes, etc.):

Research project in partnership with CEBRACE: use of waste from processed glass grinding as raw material in the glass industry.

2nd Key Person

First Name:	Lilian M.	**Surname:**	Jesus

Title:	Prof. Dr.	**E-mail[37]:**	Lilian@df.ufscar.br
Phone[38]:	+55 16 3351-8186	**Fax:**	n/a
Organizational web page of key person [39]:	http: https://www.mafa.ufscar.br/		
Personal web page[40]:	http: http://lattes.cnpq.br/1731168664454710		

C. Relevant activities:

Relevant activities in the field of thematic area: **Lilian M. Jesus** holds a PhD in Applied Physics from the University of São Paulo, São Carlos, BR, with an internship at the University of Colorado (UCB) Boulder, USA. Her doctoral research focused on electric-field assisted processing and its impact on the electrical properties of electroceramics, assessed through impedance spectroscopy. She introduced the concept of electric field-assisted ultrafast synthesis of oxides (flash synthesis) and demonstrated the feasibility of synthesizing and sintering ceramic materials in a single experiment using electric fields, known as Reactive Flash Sintering. Since 2018, she has been a Professor in the Department of Physics at the Federal University of São Carlos, BR, with a primary focus on investigating the electrical properties of ionic conductors for all-solid-state batteries. In 2019 she conducted postdoctoral research at UCB, followed by another in 2022 at the KTH Royal Institute of Technology in Stockholm, Sweden. Both positions were focused on the processing of Li-ion conductors for all-solid-state batteries. She maintains an extensive network of collaborations and has published 23 papers in peer-reviewed journals, with an h-index of 11 (web of science).

Relevant activities in the field of the project: **Lílian M. Jesus** has led projects dedicated to non-conventional ceramic processing techniques and the comprehensive characterization of materials for energy storage applications. She works on evaluating structural, microstructural, and electrical properties of ceramics.

D. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1. Yoon, B.; Avila, V.; Lavagnini, I.R.; Campos, J.V.; **Jesus, L.M.,** *Reactive flash sintering of ceramics: a review* **Adv. Eng. Mater.**, 25 [5] (2023) 2200731.

https://doi.org/10.1002/adem.202200731

[37] *Organisational e-mail ...@<partner1>*
[38] *International format*
[39] *Official web page of key person in the organisation*
[40] *Personal web page, if applicable*

2. Avila, V.; Yoon, B.; Ghose, S.; Raj, R.; **Jesus, L.M.,** *Phase evolution during reactive flash sintering of $Li_{6.25}Al_{0.25}La_3Zr_2O_{12}$ starting from a chemically prepared powder*. **J. Eur. Ceram. Soc.**, 4 (2021) 4552-4557.

https://doi.org/10.1016/j.jeurceramsoc.2021.02.054

3. Yoon, B.; Avila, V.; Raj, R.; **Jesus, L.M.,** *Reactive flash sintering of the entropy-stabilized oxide $Mg_{0.2}Ni_{0.2}Co_{0.2}Cu_{0.2}Zn_{0.2}O$*. **Scr. Mater.**, 181 (2020) 48-52.

https://doi.org/10.1016/j.scriptamat.2020.02.006

4. Avila, V; Yoon, B; Ingraci Neto, RR.; Silva, RS.; Ghose, S; Raj, R; **Jesus, LM.** *Reactive flash sintering of the complex oxide $Li_{0.5}La_{0.5}TiO_3$ starting from an amorphous precursor powder.* **Scr. Mater.**, 176 (2020) 78-82.

https://doi.org/10.1016/j.scriptamat.2019.09.037

5. **Jesus, L.M.**; Silva, R.S.; M'peko, J.-C., *Ultrafast synthesis and sintering of materials in a single running experiment approach by using electric fields*. **J. Adv. Ceram.**, 8 [2] (2019) 265–277.

https://doi.org/10.1007/s40145-018-0313-1

Relevant projects in the field of thematic area (*maximum 5*):

1. Project title: Ultrafast synthesis and sintering of high entropy oxides by using electric fields; duration: 02/2022 - 02/2025; Funding agency: CNPq (Grant no: 403978/2021-1)

2. Project title: Electrical properties of the high entropy oxide $(Mg,Co,Ni,Zn)_{1-x}Li_xO$ (x=0.3); duration: 05/2023–05/2024; funding agency: FAPESP (Grant no: 2023/02263-0).

3. Project title: Electrical characterization of laser-sintered $Li_{3x}La_{(2/3-x)}TiO_3$ ceramics by impedance spectroscopy; duration: 12/2021–11/2023; funding agency: FAPESP (Grant no: 21/11569-0).

4. Project title: Electric-field assisted processing of electroceramics: (micro)structural characteristics and dielectric properties; duration: 03/2019–12/2019; funding agency: FAPESP (Grant no: 18/19370-6).

Relevant applied activities (for companies e.g. product, processes, etc.): Co-inventor of three patents filed with the National Institute of Industrial Property (INPI), Brazil.

3rd Key Person

First Name:	Eduardo		**Surname:**	Bellini Ferreira
Title:	Professor	**E-mail[1]:**	ebferreira@sc.usp.br	
Phone[2]:	+55 16 3373-9592		**Fax:**	
Organisational web page of key person [3]:	https://www.certev.ufscar.br/en			
Personal web page[4]:	http://lattes.cnpq.br/7703580367293028			

A. Relevant activities:

Relevant activities in the field of thematic area: Eduardo Bellini Ferreira is Associate Professor in Materials Engineering Department, Engineering School of São Carlos, University of São Paulo (USP), São Carlos, SP, Brazil (since 2010). His research interests are on glass and glass-ceramics materials, mainly on the kinetics of glass sintering and crystallization, glass forming ability, the powder technology to manufacture glass and glass-ceramics and their applications, and recycling of glass or other inorganic materials to produce new glass and glass-ceramics. Since 2013, he has been the Technology-Transfer Coordinator at the Center for Research, Technology and Education in Vitreous Materials (CeRTEV), one of the Research, Innovation and Dissemination Centers (RIDC) of FAPESP.

Relevant activities in the field of the project: Eduardo Bellini Ferreira supervised the Ph.D. of M. G. Bacha entitled "Electric field-assisted commercial soda-lime-silica glass sintering" (2012-2017) and the M.Sc. work of J. M.R. Murdiga "Effect of the electric field on glass sintering in the Li2O-SiO2 system" (2019-2021). Currently, he collaborates with the efforts of Prof. Rodrigues (LaMaV/UFSCar) on the electric field-assisted synthesis of glass and glass-ceramics. He has coauthored her recent paper and patent in the field.

B. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1. J.V. Campos, I.R. Lavagnini, V.M. Zallocco, **E.B. Ferreira**, E.M.J.A. Pallone, A.C.M. Rodrigues. Flash sintering with concurrent crystallization of Li1.5Al0.5Ge1.5(PO4)3 glass. Acta Materialia 244 (2023) 118593 (4 citations)

2. M.L.F. Nascimento, L.A. Souza, **E.B. Ferreira**, E.D. Zanotto. Can glass stability parameters infer glass-forming ability? Journal of Non-Crystalline Solids, 351 (2005) 3296 (276)
3. A.M. Cruz, **E.B. Ferreira**, A.C.M. Rodrigues. Controlled crystallization and ionic conductivity of a nanostructured LiAlGePO4 glass ceramic. J. Non-Crystalline Sol., 355 (2009) 2295 (110)
4. M.L.F. Nascimento, **E.B. Ferreira**, E.D. Zanotto. Kinetics and mechanisms of crystal growth and diffusion in a glass-forming liquid. Journal of Chemical Physics, 121 (2004) 8924 (83)
5. **E.B. Ferreira**, M.L. Lima, E.D. Zanotto. DSC Method for Determining the Liquidus Temperature of Glass-Forming Systems. J. American Ceramic Society, 93 (2010) 3757 (79)

Relevant projects in the field of thematic area (*maximum 5*):

- 2013-2024 (renew requested for one more year up to 2025): Principal Investigator and Technology Transfer Coordinator – Center for Research, Technology and Education in Vitreous Materials (CeRTEV), CEPID/FAPESP 2013/07793-6, Coordinator Prof. E. D. Zanotto (UFSCar), R$ 9,289,036.02 and US$ 4,591,605.46.
- 2021-2024: Coordinator of the Research Agreement between EESC-USP, FIPAI, and the companies Bramagran, Cajugram and Magban in the Ornamental Rocks sector, entitled "Ornamental rocks obtained from mineral waste," dated 11/10/2021, term 36 months, value R$ 600,208.00.

Relevant applied activities (for companies, e.g., products, processes, etc.): Co-inventor of one patent filed with the National Institute of Industrial Property (INPI), Brazil. Patent title: "System and method for ultrafast crystallization of glasses aided by an electrical current" (in Portuguese)

4th Key Person

<table>
<tr><td>First Name:</td><td colspan="2">João Vitor</td><td>Surname:</td><td>Campos</td></tr>
<tr><td>Title:</td><td>Dr. – Eng.</td><td>E-mail[5]:</td><td colspan="2">Joao.campos@ufscar.br</td></tr>
<tr><td>Phone[6]:</td><td colspan="2">+55 16 981583116</td><td>Fax:</td><td>n/a</td></tr>
<tr><td>Organisational web page of key person [7]:</td><td colspan="4">http: http://lamav.weebly.com</td></tr>
<tr><td>Personal web page[8]:</td><td colspan="4">http: https://www.linkedin.com/in/jvitorcampos/</td></tr>
</table>

C. Relevant activities:

Relevant activities in the field of thematic area: **João Vitor Campos** holds a Ph.D. in Materials Science and Engineering from the University of Sao Paulo, Pirassununga, BR, with an internship at the University of Colorado Boulder, USA. His doctoral research primarily focused on the development of a fully automated and instrumented flash sintering setup, with an emphasis on optimizing processing parameters for yttria-stabilized zirconia. Notably, he introduced the concept of multi-step flash sintering, later recognized as current ramp flash sintering, to address hotspot formation during thermal runaway.

Since 2021, João Vitor has been a Postdoctoral fellow at LaMaV, where he contributed to the field by developing an ultrafast crystallization method for NaSICON solid electrolyte. His research efforts have resulted in 17 publications in peer-reviewed journals, with a current h-index of 7 according to Google Scholar.

Relevant activities in the field of the project: **João Vitor** brings seven years of expertise in the realm of flash sintering and related techniques to the project. Over the past two years, he has directed his efforts toward pioneering and implementing innovative, energy-efficient processing techniques for NaSICON solid electrolytes. His extensive background in these methodologies positions him as a valuable contributor, poised to apply his knowledge and skills to the specific challenges and objectives outlined in the proposed project.

D. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1. **Campos, J. V.**, Lavagnini, I. R., Zallocco, V. M., Ferreira, E. B., Pallone, E. M. J. A., Rodrigues, A. C. M. (2023). *Flash sintering with concurrent crystallization of* $Li_{1.5}Al_{0.5}Ge_{1.5}(PO_4)_3$ *glass*. **Acta Materialia**, 244, 118593. https://doi.org/10.1016/j.actamat.2022.118593

2. **Campos, J. V.**, Lavagnini, I. R., Zallocco, V. M., Jesus, L. M., Rodrigues, A. C. M. *Ultrafast crystallization and sintering of* $Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$ *glass through flash sinter-crystallization*. **Journal of the American Ceramic Society**, 2023; 1–16. https://doi.org/10.1111/jace.19393

3. **Campos, J. V.**, Lavagnini, I. R., Avila, V., Yoon, B., Ghose, S., Raj, R., Pallone, E. M. J. A., Jesus, L. M. (2021). *On the Arrhenius-like behavior of conductivity during flash sintering of 3 mol% yttria-stabilized zirconia ceramics*. **Scripta Materialia**, 203, 114093. https://doi.org/10.1016/j.scriptamat.2021.114093

4. **Campos, J. V.**, Lavagnini, I. R., Pereira da Silva, J. G., Ferreira, J. A., Sousa, R. V., Mücke, R., Guillon, O., Pallone, E. M. J. A. (2020). *Flash sintering scaling-up challenges: Influence of the sample size on the microstructure and onset temperature of the flash event*. **Scripta Materialia**, 186, 1-5.

https://doi.org/10.1016/j.scriptamat.2020.04.022

5. **Campos, J. V.**, Lavagnini, I. R., Sousa, R. V., Ferreira, J. A., Pallone, E. M. J. A. (2019). *Development of an instrumented and automated flash sintering setup for enhanced process monitoring and parameter control*. **Journal of the European Ceramic Society**, 39 (2-3), 531-538. https://doi.org/10.1016/j.jeurceramsoc.2018.09.002

Relevant projects in the field of thematic area (*maximum 5*):

1. Project title: Ionic conductor glass-ceramics sintering with concurrent crystallisation using flash sintering; duration: 08/2021 - 07/2024; Funding agency: FAPESP – Sao Paulo Research Foundation (Grant no: 2021/06509-9).
2. Project title: Instrumentation and automation of a tube furnace adapted to flash sintering: 08/2019 - 02/2020; Funding agency: FAPESP – Sao Paulo Research Foundation (Grant no: 2019/03786-1). [Funding for internship abroad – 6 months]
3. Project title: Instrumentation and automation of a tube furnace adapted to flash sintering: 05/2018 - 10/2020; Funding agency: FAPESP – Sao Paulo Research Foundation (Grant no: 2018/04331-5).

Relevant applied activities (for companies e.g., product, processes, etc.): Co-inventor of one patent filed with the National Institute of Industrial Property (INPI), Brazil. Patent title: "*Sistema e método de cristalização ultrarrápida de vidros assistida por corrente elétrica*" – System and method for ultrafast crystallization of glasses aided by an electrical current.

5th Key Person

First Name:	Isabela R		**Surname:**	Lavagnini
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Phone[10]:	+55 14 981226140		**Fax:**	n/a
Organisational web page of key person [11]:	http://lamav.weebly.com			
Personal web page[12]:	http://lattes.cnpq.br/0448676677134995 www.linkedin.com/in/isabelarlavagnini			

E. Relevant activities:

Relevant activities in the field of thematic area: **Isabela R Lavagnini** holds a Ph.D. in Materials Science and Engineering from the University of Sao Paulo, Pirassununga, BR, with an internship at the University of Colorado Boulder, USA. His doctoral research primarily focused on the field of non-conventional sintering techniques, more specifically the Flash Sintering technique. Isabela's focus was on bringing Flash Sintering closer to the industry by studying its behavior for various ceramic systems and mapping the input parameters with the obtained results. In 2023, Isabela was a Postdoctoral fellow for 6 months at the University of Sao Paulo, Pirassununga, BR. Currently, she is a Postdoctoral fellow at LaMaV, where she contributes to the field by conducting research on the application of electric fields and electric currents to crystallize glass systems. Isabela has authored 14 publications in peer-reviewed journals and currently has an h-index of 7, as reported by Google Scholar.

Relevant activities in the field of the project: **Isabela** brings seven years of expertise in flash sintering and related techniques to the project. She has collaborated on implementing innovative, energy-efficient processing techniques for sintering ceramics and crystallizing glasses. She is well-equipped to make significant contributions by applying her expertise and skills to address the specific challenges and objectives laid out in the proposed project.

F. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1. **LAVAGNINI, I.R.**; CAMPOS, J.V.; OSIRO, D.; FERREIRA, J.A.; COLNAGO, L. A.; PALLONE, E.M.J.A. Influence of alumina substrates open porosity on calcium phosphates formation produced by the biomimetic method. Progress in Biomaterials, v. 11, n. 3, pp. 263-271, 2022. https://doi.org/10.1007/s40204-022-00193-8
2. **LAVAGNINI, I.R.**; CAMPOS, J.V.; JESUS, L.M.; PALLONE, E.M.J.A. Influence of forming methods on the microstructure of 3YSZ flash-sintered ceramics. Materialia, v. 22, n. 5, pp. 101419, 2022. https://doi.org/10.1016/j.mtla.2022.101419
3. **LAVAGNINI, I.R.**; CAMPOS, J.V.; PALLONE, E.M.J.A. Microstructure evaluation of 3YSZ sintered by Two-Step Flash Sintering. Ceramics International, v. 47, n. 15, pp. 21618-21624, 2021. https://doi.org/10.1016/j.ceramint.2021.04.174
4. **LAVAGNINI, I.R.**; CAMPOS, J.V.; STORION, A.G.; LOBO, A.O.; RAJ, R.; PALLONE, E.M.J.A. Influence of flash sintering on phase transformation and conductivity of Hydroxyapatite. Ceramics International, v. 47, n. 7, pp. 9125-9131, 2020. https://doi.org/10.1016/j.ceramint.2020.12.036
5. **LAVAGNINI, I.R.**; CAMPOS, J.V.; FERREIRA, J.A.; PALLONE, E.M.J.A. Microstructural evolution of 3YSZ flash-sintered with current ramp control. Journal of the American Ceramic Society, v. 103, n. 6, pp. 3493-3499, 2020. https://doi.org/10.1111/jace.17037

Relevant projects in the field of thematic area (*maximum 5*):

1. Project title: Ultrafast sintering and crystallization with the application of an electric field in Li_2O-Al_2O_3-SiO_2 (LAS) glass system with antimicrobial properties; duration: 09/2023 –

08/2025; Funding agency: FAPESP – Sao Paulo Research Foundation (Grant no: 2022/13532-0)

2. Project title: Flash sintering of the zirconia-hydroxyapatite composite; duration: 03/2023 – 08/2023; Funding agency: CNPq - Conselho Nacional de Desenvolvimento Científico e Tecnológico (150523/2022-0).
3. Project title: Sintering of zirconia, hydroxyapatite, and hydroxyapatite-zirconia composites via Flash Sintering; duration: 07/2016 - 07/2019; Funding agency: CAPES – Coordenação de Aperfeiçoamento de Pessoal de Nível Superior.
4. Development of the multi-step flash sintering technique: Microstructural control of Hydroxyapatite; duration: 08/2019 – 02/2020; Funding agency: CNPq - Conselho Nacional de Desenvolvimento Científico e Tecnológico (203930/2018-5).

Relevant applied activities (for companies e.g., product, processes, etc.): Co-inventor of one patent filed with the National Institute of Industrial Property (INPI), Brazil. Patent title: "*Sistema e método de cristalização ultrarrápida de vidros assistida por corrente elétrica*" – System and method for ultrafast crystallization of glasses aided by an electrical current.

6th Key Person

First Name:	Vinicius		**Surname:**	M Zallocco
Title:	MSc. – Eng.	**E-mail[13]:**	Vini.zallocco@gmail.br	
Phone[14]:	+55 15 997624542		**Fax:**	n/a
Organisational web page of key person [15]:	http://lamav.weebly.com			
Personal web page[16]:	http://lattes.cnpq.br/4362459556444465			

G. Relevant activities:

Relevant activities in the field of thematic area: **Vinicius Martins Zallocco** holds a M.Sc. in Materials Science and Engineering from the Federal University of Sao Carlos, São Carlos, BR, with an internship at the University of Iowa, USA. His masters research primarily focused on the field of solid electrolytes, more specifically the electrochemical stability window of solid electrolytes. Currently, he is a Doctorate fellow at Federal

University of São Calros, where he researches solid-state ionic conductivity mechanisms in glass and glass-ceramic electrolytes and their application in solid state battery.

Relevant activities in the field of the project:

Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

1. **V.M. Zallocco**, J. V. Campos, A. C. M. Rodrigues. (2023). Determination of effective charge carrier density in a lithium disilicate glass by impedance spectroscopy. ***Under review***.
2. J. V. Campos, I. R. Lavagnini, **V. M. Zallocco**, E. B. Ferreira, E. M. J. A. Pallone, A. C. M. Rodrigues. (2022). Flash sintering with concurrent crystallization of $Li_{1.5}Al_{0.5}Ge_{1.5}(PO_4)_3$ glass. ***Acta Materialia***.
3. **V.M. Zallocco**, J.M. Freitas, N. Bocchi, A.C.M. Rodrigues. (2022). Electrochemical stability of a NASICON solid electrolyte from the lithium aluminum germanium phosphate (LAGP) series. ***Solid State Ionics***.
4. **V.M. Zallocco**, J. V. Campos, A. C. M. Rodrigues. (2023). Charge carrier density measurements in alkali silicate glasses by impedance spectroscopy. ***XVIII Conference of the European Ceramic Society (ECerS)***. (Oral)
5. **V.M. Zallocco**, A. C. M. Rodrigues. (2022). Sluggish kinetics decomposition of NASICON solid electrolyte from the lithium aluminum germanium phosphate (LAGP) series. ***International Conference on Advances in Glass and Glass-ceramics (ICAGGC-2022)***. (Oral).

Relevant activities in the field of the project: **Vinicius** is researching the impact of charge carriers and mobility on solid-state ionic conductivity for advancements in solid-state battery technology. We employ diverse characterization techniques, including Impedance Spectroscopy, Cyclic Voltammetry, X-ray Diffraction, and various microscopy methods.

Relevant projects in the field of thematic area (*maximum 5*):

Project title: Electrochemical characterization of NASICON $Li_{1.5}Al_{0.5}Ge_{1.5}(PO_4)_4$ solid electrolyte; duration: 08/2019 - 08/2021; Funding agency: CAPES – Coordenação de Aperfeiçoamento de Pessoal de Nível Superior.

Partner 4: TUD

Role in the project:

TUD will support the developments within the project by advanced characterization of the Na-plating and stripping behavior. This includes ex-situ cross-sectional SEM imaging combined with EDS analyses at different states of the pore filling process as well as operando dilatometry to study the breathing behavior of the cell during Na-plating and stripping. The impact of host properties, such as pore morphology and size distribution, microstructure, and functional surface layers, on the Na-plating and stripping behavior is analyzed by means of electrochemical impedance spectroscopy and chronoamperometry to support the understanding of effects on the cycling stability and fast-charging capability.

Team qualification in the field of proposal:

The research group Combinatorial Microelectrochemistry of the Chair of Inorganic-Nonmetallic Materials at TU Dresden (TUD) has many years of comprehensive experience in the field of electrochemical material characterization for batteries and supercaps using local in-situ and operando methods coupled with model-based analysis. Recent work includes the benchmarking and critical design considerations of zero excess Li- and Na-metal batteries and the characterization of Li plating and stripping in zero excess Li-metal batteries using liquid electrolytes, including the application of lithiophilic layers on Cu current collectors via electrochemical deposition and the characterization of Li-plating morphology via operando electrochemical dilatometry.

CV's of Key Persons involved in the activities of the project

1st Key Person

First Name:	Ulrike		**Surname:**	Langklotz
Title:	Dr.-Ing.	**E-mail[41]:**	ulrike.langklotz@tu-dresden.de	
Phone[42]:	+49 351 2553 7934		**Fax:**	none
Organisational web page of key person [43]:	https://tu-dresden.de/ing/maschinenwesen/ifww/anw			
Personal web page[44]:	none			

E. Relevant activities:

Relevant activities in the field of thematic area:

Ulrike Langklotz studied Chemistry at the TU Bergakademie Freiberg from 2002 to 2008. During her Diploma Thesis, Ulrike worked on the synthesis and crystallographic properties of metal-organic frameworks (MOFs) in the group of Prof. Mertens. In 2008 she went to the TU Dresden, where she worked in the group "Kombinatorische Mikroelektrochemie" (Prof. A. Michaelis), which is located at the Fraunhofer IKTS Dresden and headed by Dr. Michael Schneider. Here she investigated thin anodic oxide films with microelectrochemical techniques in view of their thickness and dielectric properties. Furthermore, Ulrike worked in the field electrochemical investigation of energy storage materials, namely for lithium-ion batteries. In December 2011,

[41] *Organisational e-mail ...@<partner1>*
[42] *International format*
[43] *Official web page of key person in the organisation*
[44] *Personal web page, if applicable*

Ulrike joined the junior research group ENano where she investigated lithium-ion battery materials with microelectrochemical methods. She received her PhD in 2013 with the topic: "(Micro-)electrochemical investigations on the layer thickness and dielectric properties of thin anodic oxide films on titanium and TiAlV6-4" at TU Dresden. In her academic career, she has been involved in around 30 publications and her work has been cited over 600 times. Her H-index is 12 (https://www.scopus.com/authid/detail.uri?authorId=35995481900#tab=metrics).

Relevant activities in the field of the project:

Ulrike Langklotz has worked on various projects in the field of electrochemistry (>20 projects) during her career. The topics range from lithium-ion batteries, corrosion and electroplating. This experience enables her to bring useful perspectives from other areas of electrochemistry to research at SIBs. Furthermore, she has built up experience in the processing and coordination of projects. She also has many years of experience with all project-relevant electrochemical methods.

F. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

[1] K. Waetzig, A. Rost, **U. Langklotz**, J. Schilm, Lithium loss indicated formation of microcracks in latp ceramics, in: 2017, pp. 143–150.

[2] A. Krause, **U. Langklotz**, D. Pohl, O. Tkacheva, K. Nielsch, T. Mikolajick, W.M. Weber, Surface related differences between uncoated versus carbon-coated silicon nanowire electrodes on performance in lithium ion batteries, J. Energy Storage 27 (2020). https://doi.org/10.1016/j.est.2019.101052.

[3] C. Heubner, **U. Langklotz**, A. Michaelis, Theoretical optimization of electrode design parameters of Si based anodes for lithium-ion batteries, J. Energy Storage 15 (2018) 181–190. https://doi.org/10.1016/j.est.2017.11.009.

[4] C. Heubner, **U. Langklotz**, C. Lämmel, M. Schneider, A. Michaelis, Electrochemical single-particle measurements of electrode materials for Li-ion batteries: Possibilities, insights and implications for future development, Electrochim. Acta 330 (2020). https://doi.org/10.1016/j.electacta.2019.135160.

[5] **U. Langklotz**, T. Lein, C. Schulze, M. Weiser, A. Krause, A. Michaelis, Scalable fabrication of gold nanoparticles with adjustable size distribution as catalytic nuclei for the CVD growth of silicon nanowires, Applied Surface Science 502 (2020) 144203. https://doi.org/10.1016/j.apsusc.2019.144203.

Relevant projects in the field of thematic area (*maximum 5*):

BamoSa (WING Centre: Battery - mobile in Saxony, BMBF, Grant No. 03X4637B) focuses on the development of materials and production concepts for cobalt-free lithium-ion cells and the development of new materials and cell concepts for lithium-sulphur-based cells.

KaSiLi (BMBF, grant No. 03XP0254B): Structural-mechanical cathode adaptation to silicon and lithium-based anode materials

KritBatt (BMBF, Grant No. 03XP0360B): Inline classification of coating defects to determine criticality in electrode production.

OptiEx (BMBF, grant no. 03XP0294B): Optimised manufacturing processes for high-load electrodes based on extrusion processes

Relevant applied activities (for companies e.g. product, processes, etc.):

2nd Key Person

First Name:	Tobias		**Surname:**	Lein
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Personal web page[48]:	none			

E. Relevant activities:

Relevant activities in the field of thematic area: Tobias Lein is a PhD student at Fraunhofer IKTS in cooperation with TU Dresden. He is working on the electrochemical exchange of Li/Na in cathode materials for secondary batteries. Furthermore, he is specialized in coating (lab scale) and electrochemical characterization (combination with operando analytics) of materials for LIBs and SIBs.

Relevant activities in the field of the project: Tobias Lein is working on his dissertation in the field of SIBs. In the NaKaSub project, he gained experience in the field of electrochemical Li/Na exchange and the characterization of materials for SIBs. He has also worked with in-house

[45] *Organisational e-mail ...@<partner1>*
[46] *International format*
[47] *Official web page of key person in the organisation*
[48] *Personal web page, if applicable*

developed operando cells (XRD and Raman) and carried out measurements at the synchrotron (Alba, Barcelona).

F. Scientific activities:

Relevant publications in the field of thematic area (*maximum 5*):

[1] C. Heubner, **T. Lein**, M. Schneider, A. Michaelis, Intercalation materials for secondary batteries based on alkali metal exchange: developments and perspectives, J. Mater. Chem. A 8 (2020) 16854–16883. https://doi.org/10.1039/D0TA03115A.

[2] C. Heubner, B. Matthey, **T. Lein**, F. Wolke, T. Liebmann, C. Lämmel, M. Schneider, M. Herrmann, A. Michaelis, Insights into the electrochemical Li/Na-exchange in layered $LiCoO_2$ cathode material, Energy Storage Materials 27 (2020) 377–386. https://doi.org/10.1016/j.ensm.2020.02.012.

Relevant projects in the field of thematic area (*maximum 5*):

NaKaSub (SAB, Grant No. 100345904):

The overall aim of the project is to develop a completely new way of producing Na intercalation electrodes. The approach is based on electrochemical cation substitution. A starting compound, e.g. $LiMn_2O_4$, which is easy and inexpensive to synthesize, is used. Li is electrochemically removed from the starting compound and then replaced by Na. The crystal structure of the host lattice is to be retained. In addition to the innovative electrochemical cation substitution, the originality of this approach lies in the fact that the process technology for producing electrodes for Na-ion batteries does not have to be developed from scratch. The "trick" only occurs at the end of the process chain through electrochemical cation exchange.

Relevant applied activities (for companies e.g. product, processes, etc.):

9. Letters of Intent (LoI) (if relevant)

Within the project duration of Na-CerAnode an Industry Board will be installed to give advice on exploitation activities and market needs. The industry board will be invited on demand to the annual consortium meeting to discuss about market insights and strategy building. The Blatron Tecnologia Ltda. (Brazil) has already signed a Letter of Support to be part of the Industry Board (see below). Further companies have been contacted and will join the board when the project is starting.

Blatron Tecnologia Ltda.
CNPJ 47.604.489-0001-74
Rua Alfredo Lopes 1717, Vila Elizabeth, São Carlos - SP, Brasil
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lorenzo.buscaglia@blatron.com

Letter of Support

Dear Prof. Ana Rodrigues

I hereby declare that Blatron Tecnologia Ltda. intends to support the project "NaCerAnode" founded under M-ERA.NET as a member of the advisory board.

Blatron is a Brazilian startup from São Carlos/SP, with origins in the University of Sao Paulo (USP). The company is specialized on the development, fabrication and commercialization of low-cost analytical instrumentation for scientific and educational laboratories. In particular, for electrical analysis, such as impedance spectroscopy. This technique is widely used in the characterization of solid ionic materials, as those in batteries.

I undertake not to make use of the proposal or parts thereof or any technical or commercial information provided by the coordinator or any of the other participants in the Project. The obligation of confidentiality shall be effective for a period of five years after the date of this Letter of Intent. The obligation of confidentiality does not apply to information that is or becomes available to the public or for which the disclosing party has waived confidential treatment in writing.

The "Na-CerAnode" is an original project that aims to develop a ceramic anode material with low or zero volumetric change during cycling. This proposal will significantly contribute to the development of Na-solid-state batteries, considered as a new generation of batteries for energy storage.

On behalf of Blatron Tecnologia I can confirm:
- Blatron will participate in the consortium meetings on request,
- will give advice about market needs,
- will support the consortium in the dissemination and exploitation of the project.

Best regards

Lorenzo Buscaglia

LORENZO ANTONIO BUSCAGLIA
SÓCIO-ADMINISTRADOR
BLATRON TECNOLOGIA LTDA

BLATRON
TECNOLOGIA