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To cite this article: Philippe Vereecken *et al* 2024 *Electrochem. Soc. Interface* **33** 45

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A Bright Future for Electrodeposition

by *Philippe M. Vereecken, Natasa Vasiljevic, Luca Magagnin, J. X. Kent Zheng, and Martin Leimbach*

The Electrodeposition Division (ELDP), which was founded in 1922 as the second ECS division, celebrated their centennial anniversary at the 242nd ECS Fall meeting in Atlanta, two years ago this October. For the occasion, the division organized several sessions with invited contributions to honor the achievements of 100 years of electrodeposition, but also to take a closer look at the present trendsetters and give a perspective on future challenges and opportunities in this thriving field. Our then newly established *Electrodeposition Early Career Forum* (ECF, founded in spring 2022) organized a full-day symposium with contributions from outstanding early-career researchers involved in cutting-edge research across a broad range of areas of active electrodeposition research. It turned out to be a fantastic day with invigorating talks full of ideas.

The ELDP division decided to share some of the excitement with the ECS community and asked our ECF members to suggest topics and participate in the articles for this summer edition of *Interface* dedicated to electrochemical and electroless deposition. Dr. **Kent Zheng**, assistant professor at the University of Texas, and Dr. **Martin Leimbach**, postdoc at Technische Universität Ilmenau, Germany, took up the challenge. Together with us, humble guest editors, four articles have been selected that center around three important topics: (1) electrodeposition for manufacturing and sustainability, edited by Prof. **Luca Magagnin**; (2) electrodeposition for energy applications, edited by Prof. **Natasa Vasiljevic**; and (3) new electrodeposition approaches extending the material library, edited by Prof. **Philippe Vereecken**. The articles have been authored largely by the members of the Electrodeposition Early Career Forum with the guidance and support of more experienced co-authors.

The first article, “Advancements in Electrodeposition for Precise Manufacturing and Sustainability,” discusses how advanced electrodeposition techniques help contribute to a more sustainable world. Electrodeposition from molten salts can be used for

sustainable steel fabrication. Electrodeposition from ionic liquids is used for recovering of rare earth elements from electronic waste or in synthesizing novel nanostructured materials. Hybrid approaches combining wet metallization and additive manufacturing can be employed to build functional structures in an energy efficient way and with limited materials waste. The second article, “Engineering Electrodeposition for Next-generation Batteries,” deals with the metal electrodeposition process inside batteries which use elemental metals such as Li, Na, Al, Mn, and Fe as anodes. The desired reversibility of the plating and stripping process, essential for battery cycle life, can be enhanced by 3D structured current collector architectures. Also, the effect of the electrolyte being liquid, solid, or hybrid is discussed. Electrodeposition from molten salts can also be used for the fabrication of thick metal oxide cathodes. The third article, “Electrochemically Induced Deposition (ECiD): A Versatile Method that Greatly Extends the Portfolio of Surface Coatings and Materials Fabricated by Electrochemical Deposition,” introduces the principle of the ECiD process for the electrodeposition of oxides, hydroxides, and compounds such as metal phosphates and metal-organic frameworks. The paper discusses the mechanisms of these electrochemically induced deposition reactions as well as the pro-bases used to trigger the deposition. The fourth paper, “Electrochemically Induced Templated Sol-gel Deposition of Mesoporous Silica and Nanocomposites: The New Kid on the ECiD Block,” goes a bit more into the details of the potential of the ECiD method for the deposition of compounds via electrochemically induced sol-gel reactions. Specifically, the example of gel ECiD of mesoporous silica films and silica nanocomposite films on planar and 3D electrodes is discussed. The paper concludes with the introduction of electro-blading as a new technique, a hybrid of electrochemical and sol-gel coating. Enjoy!

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The Electrodeposition ECF Luncheon at the 244th ECS Meeting in Gothenburg, 2023.

About the Authors

Philippe Vereecken was chair of the Electrodeposition Division from October 2019 to October 2021.



PHILIPPE VEREECKEN, FELLOW, IMEC, PROGRAM LINE COORDINATOR P2M, ENERGYVILLE, AND PROFESSOR, KU LEUVEN
Education: PhD in Physical Chemistry (Ghent University)

Research Interests: The combination of electrochemistry and nanomaterials and specifically in its use in semiconductors, energy conversion, electrochemical storage, and nanomaterials synthesis

Work Experience: Postdoctoral Associate in the Department of Materials Science and Engineering at The Johns Hopkins University (1998–2001) and Research Staff Member (RSM) at IBM T.J. Watson Research Center (2001–2005). He joined imec in 2005 and KU-Leuven in 2009.

Work with ECS: ELDP Division executive committee member (2008–2023)

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Natasa Vasiljevic is currently past-chair of the Electrodeposition Division and was chair of the division from October 2021 to October 2023.



NATASA VASILJEVIC, SENIOR LECTURER, SCHOOL OF PHYSICS, UNIVERSITY OF BRISTOL
Education: BS in Physics (University of Belgrade); PhD in Science and Engineering of Materials (Arizona State University)

Research Interests: Electrochemical surface science, electrodeposition of thin films and functional nanomaterials for electrocatalysis, magnetics and optoelectronics.

Work Experience: Lecturer at the School of Physics, University of Bristol (since 2011); Research Associate, Sandia National Laboratories, Albuquerque, New Mexico, US (2004–2008)

Pubs: 50 + papers, 1 book chapter

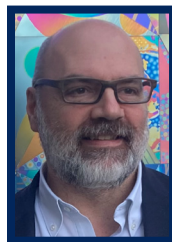
Awards: Great Western Research Fellowship, University of Bristol, UK (2008–2011)

Work with ECS: Member of the ECS ISTS Subcommittee (2019–2023), ELDP Division executive committee member (2011–2023), ELDP Division Chair (2021–2023).

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Luca Magagnin became chair of the Electrodeposition Division in October 2023.



LUCA MAGAGNIN, PROFESSOR, SURFACE ENGINEERING & APPLIED ELECTROCHEMISTRY, POLITECNICO DI MILANO

Education: MSc in nuclear engineering and PhD in electrochemical engineering (Politecnico di Milano)

Research Interests: Include electrodeposition and electroless plating, MEMS and development, fabrication and testing of innovative functional materials and coatings

Pubs + Patents: Authored or coauthored >250 publications

Work with ECS: Chair of the Electrodeposition Division of ECS

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J. X. Kent Zheng is a member of ECS Electrodeposition Division Early Career Forum Organizing Committee.



J. X. KENT ZHENG, ASSISTANT PROFESSOR, MCKETTA DEPARTMENT OF CHEMICAL ENGINEERING, DEPARTMENT OF PHYSICS, AND TEXAS MATERIALS INSTITUTE, UT AUSTIN
Education: PhD (Cornell University)

Research Interests: Understanding and controlling the physicochemical processes involved in electro-crystallization
Pubs: 60+ papers, 4000+ citations

Awards: Recipient of the ECS Electrodeposition

Early Career Investigator Award

Work with ECS: Member of ECS and ECS Electrodeposition Division Early Career Forum Organizing Committee

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Martin Leimbach is a member of ECS Electrodeposition Division Early Career Forum Organizing Committee.



MARTIN LEIMBACH, POSTDOCTORAL RESEARCH FELLOW, TU ILMENAU

Education: Undergraduate, master's, and PhD degrees in Materials Science and Engineering (Technische Universität Ilmenau), completing his PhD under the supervision of Prof. Dr.

Andreas Bund in the Electrochemistry and Electroplating Group.

Research Interests: Functional coatings for water electrolysis, corrosion protection, alloy

plating, electroless deposition processes, and pretreatment of metal surfaces.

Awards: Schwäbisch Gmünd Prize for Young Scientists (2020), DGO Nasser Kanani Prize (2022)

Work with ECS: President of the ECS Ilmenau Student Chapter.

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