Topical Symposium on Sustainable Surface Engineering
Room Town & Country C - Session TS3-TuA

Circular Strategies for Surface Engineering

Moderators: Marcus Hans, RWTH Aachen University, Germany, **Arnaud Le Febvrier**, Uppsala University, Sweden

1:40pm **TS3-TuA-1 Rethinking Resources: Circular Strategies in Target Material Production**, ***Lukas Zauner [l.za@rhp.at]***, *Marie Friedl, Laszlo Sajti, Mariangela Fedel, Emanuel Feuerstein, Michael Kitzmantel, Erich Neubauer,* RHP Technology, Austria **INVITED**

The continuing expansion of thin-film technologies across diverse industries is intensifying the demand for reliable supply chains of high-quality target materials. At the same time, targets are frequently manufactured from scarce, geopolitically restricted, precious or energy-intensive materials, rendering conventional extract–produce–dispose supply models increasingly unsustainable. In addition, technological limitations such as an inefficient utilization of sputter targets – often at levels of only 20-40% – necessitate process innovations and direct recycling strategies to retain valuable material of spent targets in a closed loop.

This presentation explores how innovative approaches contribute to enhancing circularity across the life-cycle of target materials, reduce environmental impacts and support stable supply. We evaluate powder-technological processes with respect to repurposing industrial waste into valuable target materials or the feasibility to directly recycle and re-use spent targets in the production process. Furthermore, efficiency improvements of geometry-driven target optimization through detailed magnetic field and erosion simulations are highlighted. Finally, we present conversion technologies such as laser-ablation-based nanoparticle formation as alternative processing routes for high-value scrap material.

Selected case studies from industry and research demonstrate both the technical and ecological potential of integrating circular strategies into target production, while maintaining stringent performance requirements for advanced thin-film applications. Together, these approaches underline that improving circularity is not only feasible and impactful for target materials, but also an important aspect to future-proof thin-film manufacturing against volatility in raw material supply and environmental constraints.

2:20pm **TS3-TuA-3 Opportunities of Combinatorial Thin Film Materials Design for the Sustainable Development of Magnesium-Based Alloys**, ***Marcus Hans [hans@mch.rwth-aachen.de]***, RWTH Aachen University, Germany*; Philipp Keuter,* GTT-Technologies, Germany*; Aparna Saksena,* Max Planck Institute for Sustainable Materials, Germany*; Janis Sälker, Markus Momma,* RWTH Aachen University, Germany*; Hauke Springer,* Universität Duisburg-Essen, Germany*; Jakub Nowak, Daniela Zander,* RWTH Aachen University, Germany*; Daniel Primetzhofer,* Uppsala University, Sweden*; Jochen Schneider,* RWTH Aachen University, Germany

Magnesium-based lightweight structural materials exhibit potential for energy savings. However, the state-of-the-art quest for novel compositions with improved properties through conventional bulk metallurgy is time, energy, and material intensive. Here, the opportunities provided by combinatorial thin film materials design for the sustainable development of magnesium alloys are evaluated. To characterize the impurity level of (Mg,Ca) solid solution thin films within grains and grain boundaries, scanning transmission electron microscopy and atom probe tomography are correlatively employed. It is demonstrated that control of the microstructure enables impurity levels similar to bulk-processed alloys. In order to substantially reduce time, energy, and material requirements for the sustainable development of magnesium alloys, we propose a three-stage materials design strategy:

(1) Efficient and systematic investigation of composition-dependent phase formation by combinatorial film growth.

(2) Correlation of microstructural features and mechanical properties for selected composition ranges by rapid alloy prototyping.

(3) Establishment of synthesis–microstructure–property relationships by conventional bulk metallurgy.

2:40pm **TS3-TuA-4 Life Cycle Analysis for Next Generation Sustainable Flexible Food Packaging Materials**, ***Glen West [G.West@mmu.ac.uk]***, Manchester Metropolitan University, UK **INVITED**

This work describes an extensive Life Cycle Analysis (LCA) study into the Product Life Cycle (PLC) of sustainable, recyclable, mono-material, flexible food packaging solutions for a circular economy. Comparison is drawn to existing, non-sustainable solutions. The LCA process, and in particular the establishment of life cycle inventory is discussed, drawing on primary source data and trial data from across the industry and comparing to published inventory data. The end of life of the packaging solutions will be evaluated against industry legislations and standards with improvements to be suggested.

A major aim of this work is to provide academia and industry an evaluation and best practice on how to undertake an LCA for packaging to address the overall lack of knowledge in this area.

4:00pm **TS3-TuA-8 Advanced Chemical and Environmental Design of Coatings: From TG-Mass Spectrometry Through Thermodynamic and Life Cycle Analysis Application**, ***Francisco Javier Perez Trujillo [fjperez@ucm.es]***, Calle Cantalejo 11, Spain **INVITED**

The design of coatings for steam turbines have been based in the past on the testing different chemical compositions. In the recent years, the application of computational tools to predict most favorable chemical compositions have been applied. In this way the role of the themodynamic calculations to simulate the interaction at high pressure steam with alloy surfaces have been a successful tool to know the liquid, solid and gas phases formed in the equilibrium of the high temperature corrosion conditions. From those results the first approach of the chemical compositions of coatings have been done. Moreover, in order to validate the volatile oxyhidroxydes species formed, TG-Mass spectrometry have been applied in order to validate the computational results and to optimize the coatings compositions. At the end a LCA-Life Cycle Analysis have been perfomed in order to know the CO2-foot print and the environmental impact of the final coatings design. In order to know the combination of computational tools with experimental advanced characterization techniques, the application to uncoated and coated steels by metallic and ceramic coatings will be show.

4:40pm **TS3-TuA-10 Reversible Solid Oxide Cells for Hydrogen Production and Storage Developed by Reactive Magnetron Co-Sputtering**, ***Justyna Kulczyk-Malecka [j.kulczyk-malecka@mmu.ac.uk]***, *Kleitos Panagi, David Shaw, Peter Kelly,* Manchester Metropolitan University, UK

Reversible solid oxide cells (RSOC) are promising technology for high-efficiency energy conversion and storage, enabling electrolysis and fuel cell operation within a single device. In this work, ultrathin (~1-3 μm) anode functional layers (AFL) were deposited using oblique angle reactive magnetron co-sputtering, enabling precise control over the cell microstructure at the nanoscale. The AFLs were deposited onto commercial YSZ electrolyte support cell and consisted of V-doped Ni/YSZ composite to reduced Ni content and its agglomeration during the long-term cycling, and therefore, to improve cell durability. The study shows that V-doped cells showed superior electrochemical performance relative to benchmark Ni/YSZ in fuel cell mode, delivering higher power densities under H_2-rich conditions. In electrolysis mode the cells sustained electrolysis current densities approaching 0.5 A cm^{-2} at 850°C under steam-rich conditions, exhibiting good polarisation behaviour without immediate voltage rise. During prolonged operation in high steam content (up to 90%) the cells demonstrated enhanced tolerance to high oxygen chemical potential and improved resistance to redox induced anode degradation.

The post-mortem analysis of RSOCs using FIB-SEM/EDS, TEM and XPS revelated that low vanadium contents promote homogeneous dopant distribution and stabilise the Ni/YSZ microstructure, whereas higher vanadium loadings promote surface enrichment and secondary phase formation associated with accelerated cell degradation. The key findings indicate that optimised microstructure and composition of the AFLs facilitate increased performance and durability presenting a promising pathway towards RSOCs for hydrogen generation, utilisation and storage.

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