INSTITUT POLYTECHNIQUE DE PARIS

RESEARCH DAY

Researcher Biographies and Project Abstracts

Symposium "Materials and Sustainability"

December, 1st
4.00 pm to 6.00
Lecture hall 3

Chaired by
Nathanaelle Schneider, CNRS Researcher at IPVF,
a laboratory of École Polytechnique, E4C

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Polina Volovitch is a full professor at Chimie ParisTech, PSL University. Her research focuses on the mechanistic understanding of the factors controlling stability and degradation of complex and multimaterials via in situ and in operando and multiscale ex situ chemical characterisation. She extends corrosion science approaches to reactivity evaluation and durability control of materials, which are traditionally excluded from the metallic corrosion field, such as photovoltaic materials, systems and infrastructures. She is a vice-chair of the « Corrosion in Green and Low Carbon Energy Technologies» working party of the European Federation of Corrosion (EFC) and the member of the Strategic Orientation Committee of PNR AgriPV (the French National Research, Teaching and Development Pole on Agrivoltaisme).

Knowledge gap and data collection and treatment needs for durability evaluation in emerging photovoltaic applications (AgriPV ad FloatingPV)

The necessity to satisfy growing demand in clean and affordable energy and to feed increasing world population implies to share the land and to install photovoltaic (PV) energy production in marine and agricultural environments which are reputed for their high to extreme corrosiveness. A typical 25-year warranty is usually allegedly given based on a rural solar PV site which corrosivity is significantly lower than in emerging applications. As an example, the immediate co-habitation of PV installations and agricultural activities increasing the presence of aggressive chemicals (fungicides, pesticides, fertilizers, ...) and these environments and their effect on the long-term stability of the materials and infrastructures are not really known. To avoid premature aging and develop adequate evaluation of service time and maintenance strategies, it is important to deeply understand material - environment interactions, select rate determining factors and construct predictive models or at least to map the risks. To achieve this, the first need is to map these new and specific environments in the emerging PV applications (agrivoltaic and floating PV) and to understand degradation mechanisms of the most used materials in these environments. On this basis new accelerated tests and predictive models need to be proposed. Such an approach requires to obtain a huge quantity of experimental data, placing the questions of the necessary data selection, their quality, strategies of storage and sharing, as well as their treatment and use in models' development as a central problem for future advancement. The talk will introduce agrivoltaics (AgriPV) and illustrate the needs of the data on the degradation in the context of multidisciplinary problematics of the development of AgriPV.

Engineer from École nationale des ponts et chaussées and École Polytechnique (Paris, France), **Matthieu Vandamme** obtained his Ph.D. in civil engineering from MIT (Cambridge, MA) in 2008, where he focused on the mechanical characterization of cement-based materials at the submicrometric scale.

Since then, he has worked as a researcher at École nationale des ponts et chaussées (ENPC) in Laboratoire Navier (ENPC, UGE, CNRS), where he applies poromechanics to materials relevant for construction and subsurface energy applications (i.e., cement-based materials, soils, geomaterials...). He is interested in the in-pore physical processes that occur in those porous materials (e.g., adsorption, capillarity, crystallization). He also studies their time-dependent behavior.

Since 2022, he has been vice-head of the Civil Engineering and Construction teaching department at ENPC.

Numerical modeling of various phenomena associated with the freezing of cement-based materials

Concrete is the most consumed material on Earth after water: each year worldwide, we pour 1 to 2 cubic meters of concrete per person. Given those massive amounts, the environmental impact of concrete is significant. One way to limit the environmental impact of concrete could be to increase its lifespan, i.e., to improve its durability. Among the various attacks to which concrete can be subjected, one is freezing. Indeed, depending on its properties and on the environmental conditions, a piece of concrete can be significantly damaged after just a few freeze-thaw cycles. In this presentation, we aim to provide an overview of numerical studies of phenomena associated with the freezing of cement-based materials, spanning multiple scales.

We will successively focus on:

1) molecular simulations of freezing of water-filled nanometric pores in cement,
2) pore-scale simulations of dissolution of air bubbles entrained in immersed concrete, and
3) poromechanical simulations of pervious concrete subjected to freezing.

Bruno Levieil is Associate professor at ENSTA, Brest, and researcher at the Institut de Recherche Dupuy de Lôme (IRDL), he works within the “Behaviour and Durability of Materials” research group. His research focuses on the relationships between manufacturing processes and the service life of metallic materials, with particular interest in understanding how processing parameters influence durability and mechanical behaviour. More recently, he has initiated the THERMOS project, which focuses on the solid-state recycling of metals, aiming to develop new applications for recycled metals by improving their mechanical performance and forming capabilities.

In parallel with his research activities, he is involved in the socio-ecological transition training program at ENSTA Bretagne. In this capacity, he leads the development of courses addressing systemic challenges, eco-design, and life cycle assessment (LCA).

From Durability Optimization to Solid-State Recycling: Pathways to Lower Environmental Footprints

Significant reductions in environmental impact can be achieved through optimized material selection and the adoption of innovative manufacturing processes. Two main approaches can be distinguished. The first involves deepening material knowledge to enable controlled design margins and thereby extend the service life of components. The second focuses on the qualification of new materials, manufacturing processes, or surface treatments that offer environmental benefits. At IRDL, the “Behaviour and Durability of Materials” research group explores both approaches to reduce the environmental footprint of industrial systems.

This presentation will address these pathways through the use of thermomechanical stress analysis based on infrared imaging. This technique enables the investigation of failure mechanisms and the monitoring of crack initiation and propagation. It has contributed to the improvement of fatigue models applied to various industrial transport components, including automotive elastomer parts, additively manufactured naval propellers, and 3D-woven composites for aeronautical applications.

The second part of the presentation will focus on the development of new recycling processes based on the solid-state transformation of metals without remelting. Beyond the environmental advantages associated with reduced energy consumption compared with conventional arc-furnace recycling, these processes also enable new applications for recycled metals by improving their mechanical performance and forming capabilities.

Clémence Badie, is a Tenure-Track Assistant Professor at Condensed matter physics laboratory (PMC), École Polytechnique. Her research focuses on the development of nanometric thin films using Atomic Layer Deposition (ALD) for energy transition applications. She first specialized in ALD during my PhD, where she developed a H_2-selective membrane (2018-2022). She expanded her skills in ALD during her postdoctoral research, which focused on the deposition and the characterization of electroactive thin films (2022-2025). She will investigate now the relationship between thin films -such as single or multi-elemental nitrides- and their electrochemical properties. In parallel, She is teaching at the Chemical Department of École Polytechnique.

Thin films for the energy transition: atomic layer deposition, a well-suited technique

The ecological transition demands transformative approaches to energy production and storage. Among the most promising solutions are electrochemical technologies such as water electrolysis for green hydrogen (H_2) and Li-ion batteries for electricity storage. To optimize their performance-to-cost ratio, a key strategy is minimizing material usage through advanced thin film deposition techniques. This approach is particularly effective for electrochemical systems, where reactions occur at the solid/liquid interface. By designing electrodes with complex 3D substrates and coating them with nanoscale electrocatalysts, surface area and efficiency can be maximized. Chemical vapor deposition (CVD) techniques, especially atomic layer deposition (ALD), are well-suited for this challenge. Originally driven by microelectronics, ALD enables precise, conformal deposition of thin films (< 50 nm) on complex architectures, making it a powerful tool for energy applications. This presentation will highlight the role of thin films in energy technologies, with a focus on the potential of ALD, among other techniques, to bridge materials science, electrochemistry, and sustainable engineering.

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