SEMINAR

APPLIED MATHEMATICS AND MECHANICS

FS1015 26 September 2025

A DCAMM seminar No. 791 will be presented by

Professor Lorenzo Bardella
Department of Civil, Environmental, Architectural Engineering and Mathematics
University of Brescia, Italy

The title of the lecture is

Electrochemo-poromechanics of ionic polymer metal composites:
Theory, numerics, and parameters identification

Abstract:
Ionic polymer metal composites (IPMCs) consist of an electroactive polymeric membrane plated with metal electrodes and including a fluid phase, constituted by ions dispersed in a solvent, whose motion allows for actuation and sensing applications.

Here, the IPMC behaviour is studied through a finite-deformation electrochemo-poromechanical theory that couples the linear momentum balance, the mass balances of solvent and mobile ions, and the Gauss law. This provides the capability to model peculiar IPMC features, such as the back-relaxation in actuation and the discharge under a sustained mechanical stimulus in short-circuit sensing, both phenomena being aided by the cross-diffusion of solvent and ions. The proposed formulation, with respect to other recent efforts, abandons the assumption that the fluid phase is a dilute solution, leading to significant benefits on both the modelling and the computation.

A reliable finite element (FE) implementation of theories suitable to capture the IPMC multiphysics is particularly challenging because the IPMC behaviour is governed by boundary layers (BLs) occurring in very thin membrane regions adjacent to the electrodes, where steep gradients of ion and solvent concentrations occur. To address this issue, here, the generalized FE (GFE) method is adopted to discretise the BLs. The GFE implementation allows both the application of large external actions compatible with experiments (e.g., up to about 3 V drop across the electrodes in actuation) and the achievement of accurate predictions in a reasonable computational time and for wide ranges of model parameters, including the membrane permittivity which governs the BL thickness.

Finally, we propose an identification procedure and quite successfully apply it to experimental data from the literature that are concerned with IPMCs of variable membrane thickness and subjected to peak voltage drop across the electrodes ranging from 2 to 43.5 V (under alternating current). Additionally, the used experimental data concern two actuation set-ups: one in which the IPMC is in a cantilever configuration and the displacement of its free end is measured, the other referring to a propped-cantilever IPMC where the reaction force developed by the support, denoted as the blocking force in the IPMC literature, is measured.

DATE: **Monday, 6 October 2025**

TIME: **13:00 – 13:45**

PLACE: **Building 414, Room 055E**
DTU, Technical University of Denmark

Danish pastry, coffee and tea will be served 15 minutes before the seminar starts.

All interested persons are invited.

Jan Becker Høgsberg