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Dynamics of electrochemical interfaces

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Interface processes play an important role in many electrochemical applications like batteries, fuel-cells or water purification. In boundary regions typically sharp layers form where electrostatic potential develops steep gradients and the ionic species accumulate to an extend that saturation effects become relevant. In contrast, the classical Nernst-Planck model for electrolyte transport is build on the assumption of dilute solutions and thus it is unable to accurately describe electrochemical interfaces.
Various modifications of the standard Nernst-Planck systems have been proposed. Recently, we derived an extended continuum model from consistent coupling of electro- and thermodynamics in bulk domains intersected by singular surfaces. We apply the model to the interface between a liquid electrolyte and a metal electrode. The interface consists of the surface and the adjacent boundary layers. The surface is assumed to be blocking to all species such that no Faradayic surface reactions occur but adsorption-desorption between volume and surface is permitted. By means of matched asymptotic analysis, the dynamic behavior of such electro-chemical interfaces is investigated in the thin double layer limit, i.e. for small Debye length. We find three different time scales characterizing the time scales of the bulk diffusion, the double layer charging and the bulk polarization.
For small amplitudes of the applied potential, a linearization of the asymptotic thin double layer model leads to an equivalent circuit model. Electrochemical impedance spectroscopy then allows the identification of parameters in the original full PDE model.

This is a joint work with W. Dreyer and C. Guhlke (WIAS Berlin).

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