Shape-optimization of nanochannels in polymer electrolyte membranes for fuel cells

Sven-Joachim Kimmerle

We study the equilibrium shape of an interface that represents the lateral boundary of a pore channel embedded in an elastomer. This problem arises in the optimization of polymer electrolyte membranes as used in hydrogen fuel cells. The model consists of a system of coupled PDEs, comprising the static linear elasticity equation within the elastomer and a nonlinear Poisson equation for the electric potential within the channel filled with protons and water.

To determine the equilibrium interface, a variational approach is employed. We analyze:

i) the existence and uniqueness of the electrical potential,

ii) the shape derivatives of state variables and

iii) the shape differentiability of the energy and the corresponding Euler-Lagrange equation.

The latter leads to a modified Young-Laplace equation on the interface. We compute several equilibrium shapes in 2d and 3d by finite element methods, using a fixed point algorithm.

This is joint work with Arian Novruzi (University of Ottawa) and Peter Berg (NTNU).