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NMR mapping of ionic currents and electro-osmotic flow in microsystem channel networks

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Magnetic resonance tomography is known to provide images the contrasts of which are determined by a combination of several parameters. On the one hand these can be system parameters like spin density, relaxation times and diffusion coefficients. On the other hand, the contrasts will be affected by experimental parameters like echo time, repetition time, and by the type of the radio frequency pulse sequence used to generate the signals. In contrast to this, we are interested in "maps" where a well defined system parameter is quantitatively encoded in gray shades or colors. A frequently employed technique of this sort is mapping of pressure induced flow. Apart from this, the objective of the present study is to examine and compare maps of the ionic current density and electro-osmotic flow in channel networks on a microscopic length scale. As a paradigm for complex pore spaces, model objects of random and correlated site percolation clusters were fabricated and filled with electrolyte solutions. The experimental maps were compared with computational fluid dynamics simulations based on finite element techniques. The patterns observed in maps of the current density, pressure induced and electro-osmotic flow velocity strongly deviate from each other. This is due to the different transport resistance characteristics and the different nature of the driving forces. The patterns of the spatial distribution of the electric current density measured in the pore space of plastic objects (no electro-osmotic flow superimposed), for example, is totally different from those found in ceramic objects (electro-osmotic flow superimposed). Vortices and recirculation patterns have been observed for all transport quantities, but at different sites. The findings can be explained and elucidated on the basis of the computational fluid dynamics simulations and experiments with test objects especially designed for this purpose.

(1) B. Buhai and R. Kimmich, Phys. Rev. Letters **96**, 174501 (2006).
(2) B. Buhai, T. Binser, and R. Kimmich, Appl. Magn. Reson., in press.