

Time-domain Electrostatic Force Spectroscopy on Solid Electrolytes using an Atomic Force Microscope

A. Taskiran¹, A. Schirmeisen¹, H. Fuchs¹,
B. Roling², S. Murugavel², H. Bracht³, F. Natrup³

¹Center for NanoTechnology (CeNTech), University of Münster, Germany

²Institut für Physikalische Chemie, University of Münster, Germany

³Institut für Materialphysik, University Münster, Germany

taskiran@uni-muenster.de

Ion conducting solid materials are widely used as solid electrolytes in batteries, fuel cells, and chemical sensors. Of particular interest are so-called fast ion conductors with conductivities that are comparable to liquid electrolytes. An important prerequisite for further progress in this field is a better understanding of the ion transport mechanisms on microscopic length scales. The macroscopic averaging over the motions of all ions in a sample leads to a loss of information making it desirable to develop techniques that are capable of probing the ion transport on nanoscopic length scales.

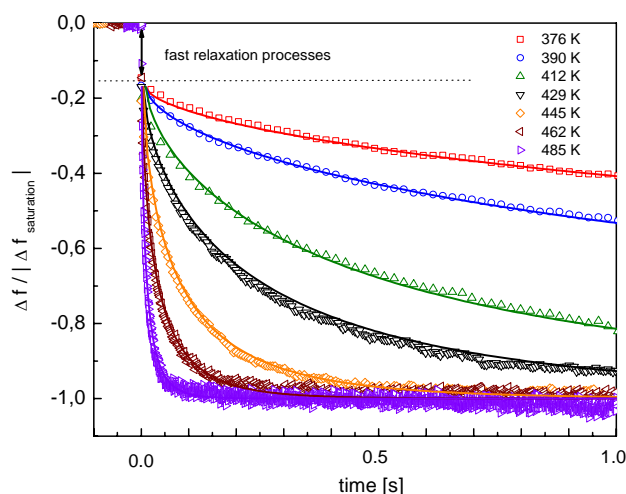


Figure 1. The illustration shows the relaxation curves on homogeneous silicat glass [1].

agreement of the activation energies for two homogeneous glasses with values from macroscopic measurements. On a different sample, a nanostructured glass-ceramic which contains two separate ion-conducting phases, we can detect the ion motion in both phases, which is not possible with macroscopic techniques. The measurements therefore shows that electrostatic force spectroscopy is capable of probing the ion dynamics and transport in nanoscopic subvolumes of solid electrolytes.

We are using non-contact AFM in UHV as time dependent electrostatic force spectroscopy to measure the ionic conductivity in nanoscale volumes of homogeneous glasses and heterogeneous glass-ceramics, which contain nanocrystallites. While the tip is oscillated close to the ion conductor surface, the tip voltage is suddenly changed. This causes a shift in the resonant frequency as a function of time (see figure 1), due to the movement of the ions in the sample. The measurements are carried out at different sample temperatures ranging from 240 K to 650 K, which allows us to extract the activation energy of the ion hopping motion. Our results indicate a good

[1] Schirmeisen et al., Appl. Phys. Lett. **85** (2004) 2053

[2] Roling et al., Phys. Chem. Chem. Phys. **7** (2005) 1472