CM1.8.10

Real-Time Observation of Resistive Switching in TiO_2 Nanoparticles Using Electron Holography

Janghyun Jo [1],Vadim Migunov [2],Dirk Schmidt [3],Ulrich Simon [3],Miyoung Kim [1], Rafal Dunin-Borkowski [2]

[1] Materials Science and Engineering Seoul National University Seoul Korea (the Republic of),
[2] Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons and Peter Grünberg Institute Forschungszentrum Jülich Juelich Germany,
[3] Inorganic Chemistry RWTH Aachen University Aachen Germany

Resistive switching phenomena in binary and complex metal oxides have attracted great interest for applications in next-generation non-volatile memory devices. Recently, nanoparticles have been adopted as switching materials, both for use in smaller devices and as model systems for understanding resistive switching mechanisms in nanoscale materials [1,2].

Here, we investigate the origin of resistive switching behavior in individual nanoparticles that have an electrical bias applied to them in situ in the transmission electron microscope (TEM). We use current-voltage (I-V) measurements in the TEM to study resistive switching mechanisms in real time while simultaneously applying electron energy-loss spectroscopy (EELS) and off-axis electron holography to the same particles. The latter technique allows projected electrostatic potential distributions in materials to be recorded with nm spatial resolution [3], providing information about the role of heterointerfaces and conducting nanofilaments during switching processes.

We study TiO_2 nanoparticles that were synthesized using a sol-gel method and then vacuum annealed. We observe reproducible forming-free bipolar switching behavior in individual nanoparticles that are contacted electrically in the TEM using a moveable electrical probe. I-V curves obtained from single particles are correlated with local EELS and electrostatic potential measurements, providing direct information about nanoscale microstructural, compositional and electrical changes occurring single nanoparticles during resistive switching.

[1] E. Goren *et al. Appl. Phys. Lett.*, **105**, 143506 (2014)
[2] Q. Hu *et al. Semicond. Sci. Tecnol.*, **30**, 015017 (2015)
[3] M. R. McCartney *et al. Annu. Rev. Mater. Res.*, **37**, 729 (2007)