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Stressing interfaces to change microstructures or grow nanostructures

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Atomic-scale defect configurations determine the properties and functionalities of materials. The application of stresses such as elevated temperature, modified gas phases, or externally applied electric fields can alter interface structures and, therefore, modify microstructures and macroscopic materials properties.

Using bicrystal experiments we have previously demonstrated that electric fields directed across grain boundary planes can alter the atomic and electronic structures of (100) twist grain boundaries in $SrTiO_3$[1]. Electric fields directed along the interface plane alter the atomic and electronic grain boundary structures as a function of field strength and proximity to the positive and negative electrodes. EELS and XPS have revealed field-induced oxygen ion migration along the interface planes[2]. Electric fields directed along a 24° tilt grain boundary in $SrTiO_3$ also show a field-induced transition of the grain boundary core structures between the two non-contacting electrodes. Results suggest anisotropic vacancy migration.

In another project *in-situ* SEM and TEM experiments have revealed one-directional growth of single crystalline nickel oxide nanostructures from individual Ni nanoparticles. Nanostructure growth was driven by either the application of electric currents or at high temperature in the presence of water vapor. The application of electrical bias to individual nanoparticles led to dielectric breakdown of native surface oxides and subsequent unidirectional mass transport due to a combination of electromigration and Ludwig-Soret diffusion[3]. In the presence of water vapor high-aspect ratio growth of NiO from metal particles was favored on select surfaces with sufficiently high total surface energies[4]. *In-situ* high resolution TEM was used to directly observe layer-by-layer growth at the buried NiO/Ni interface. Individual layers of NiO were observed to grow by disconnection migration along the oxide/metal interface plane. At interfacial steps oxidation of Ni is governed by oxygen vacancy migration along the interface plane. The junction between the oxide/metal interface and the gas phase serves as nucleation site. The results demonstrate terrace-ledge-kink crystal growth for reactive crystal growth processes at internal heterophase interfaces[5].

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