Nanomaterials and advanced characterization: M - Defect-induced effects in nanomaterials

Tuning the structural, electronic and optical properties of transition metal oxides via thermal reduction

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Many widely used nanomaterials are based on transition metal oxides (TMOs), because of their abundance but most notably due to the ease of tuning their properties via reduction-oxidation processes. During such, the density of oxygen vacancies is changed, contributing to the substantial changes in the electronic and structural properties and tailoring them to meet specific needs e.g. in (photo)catalysis, energy production and storage.

In this presentation the impact of thermal reduction on the surface and bulk properties of two model oxide materials, TiO_2 and $SrTiO_3$, will be presented. SPM-based methods prove that the evolving oxygen nonstoichiometry leads to the dramatic increase in conductivity and drop in the work function. Not only the carrier concentration and bandgap width are affected but simultaneously the exciton lifetimes extend, measured by the two-photon fluorescence microscopy. All of the mentioned effects could be beneficial to the catalytic performance of metal oxide-based nanostructures.

Prolonged thermal reduction leads ultimately to the structural transformation of transition metal oxide crystals. We introduce the ELOP (Extremely Low Oxygen Partial Pressure) process on the example of TiO (titanium monoxide) nanowires emerging on the surface of $SrTiO_3(100)$. Such oxide heterostructure provides an interesting metal/insulator junction with a sharp interface and a 0.6 eV work function difference, as proved by LC-AFM and KPFM methods.