Nano scale epitaxial films of Cu_2O_{2-x}; a model system

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Here we present a detailed study on the growth of epitaxial CuO_x thin films on single crystal substrates by MBE. *In situ* photo electron spectroscopy (XPS and UPS) is used to establish the degree of oxidation of Cu while *in situ* electron diffraction (X-ray Photo electron diffraction and RHEED) monitor the crystal structure and morphology of the growing thin film. We particularly pay attention to the valence state of Cu and the crystal symmetry as influenced by a combination of activated oxygen (O^*) and/or a flux of low energy Ar^+ ions. We observe a rich variety of epitaxial relationships as a function of the flux ratios of three species on the substrate surface (ie, Cu, O^* and Ar^+) which will be used to explore the possibility of the highest crystal symmetry possible in CuO_x system. In recent experiments we observe a new CuO phase (di-valent copper) for the first deposited unit cell layers which is found to be 45 degrees rotated with respect to the $SrTiO_3$ substrate lattice. Both RHEED as well as preliminary X-ray Photoelectron Diffraction confirm a four fault symmetric structure. In parallel we try to establish the relationship between (electronic) properties and crystal structure at different length scales. Although the copper system is the focus of this paper, we will also address whether such an approach is feasible for other oxide materials, for example dielectric materials.