Chemical Characterization of Nanostructures by Photoemission X-ray Microscopy

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In my talk I will first introduce the basic features of the spectroscopic photoemission and low energy electron microscope (SPELEEM) operating at the Nanospectroscopy Beamline at Elettra. The SPELEEM is a LEEM system (Elmitec company) equipped with an imaging energy filter. The SPELEEM can be operated in different imaging modes: XPEEM (x-ray photoemission electron microscopy), PED (photoelectron diffraction), and small spot micro-XPS. An important advantage of the SPELEEM is the incorporated electron gun, which adds LEEM and micro-LEED techniques for obtaining structural information from the same sample area where XPEEM is performed. This makes the experimental station a real multi-technique spectromicroscopic probe.

Then I will illustrate the potential of the SPELEEM discussing one prototypical application: The chemical characterization of nanostructures created by local anodic oxidation (LAO). Local anodic oxidation allows the modification of a sample surface on the nanometer scale taking advantage of the unique possibilities of scanning probe microscopy. Among the various applications of LAO, a promising field is the fabrication of nanodevices on GaAs/AlGaAs heterostructures with a shallow two-dimensional electron gas (2DEG).

Our measurements with the SPELEEM on several AFM-grown structures on GaAs revealed an unexpected strong desorption effect due to the irradiation of the oxide areas with extreme ultraviolet light (130eV = 9.5nm). This desorption is linearly related to the exposure time. A time-resolved study of the oxide reveals that the AFM-oxides are particularly rich in gallium oxides with a dominant component related to Ga_2O. The intensity of the arsenic oxides is only 20% with respect to that of the gallium oxides, and the arsenic oxide contribution disappears as the exposure time increases. These results suggest that the AFM-oxide is a quite homogenous layer mainly composed of Ga_2O with traces of arsenic oxides located close to the surface.