Local Anodic Oxidation of GaAs: A Nanometer-Scale Spectroscopic Study with PEEM

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The rapid progress of experimental techniques with access to chemical composition, electronic structure, magnetization, and fluctuations in these properties at nanometer and sub-micron scales has been driven by the demand imposed by modern technology. Photoemission electron microscopy (PEEM) is among the oldest methods in electron microscopy. In recent years it has seen a strong revival with an increasing role of synchrotron radiation, which has been facilitated by the construction of third generation synchrotron light sources. In my talk I will first review the present situation and future developments of photoemission electron microscopy in combination with synchrotron radiation. In particular, I will discuss the role of energy filtering, which allows to perform photoelectron spectroscopy with 25 nm lateral resolution in a PEEM. Then I will illustrate the potential of photoemission electron microscopy by discussing one selected experiment in detail:

Local anodic oxidation (LAO) 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). On these samples, the oxide structures can be used to electrically separate different regions of the 2DEG allowing the definition of mesoscopic systems such as quantum point contacts [1].

In order to gain a deeper insight of the structural and chemical properties of the AFM oxide, we performed photoemission spectroscopy on several AFM-grown structures taking advantage of the high energy and lateral resolution of the spectroscopic photoemission and low energy electron microscope (SPELEEM) at the Nanospectroscopy Beamline at Elettra. We found a strong desorption effect due to the irradiation of the oxide structures with extreme ultraviolet light [2]. A time-resolved photoemission study of the oxide reveals that the AFM-oxide is a homogenous layer mainly composed of Ga_2O with traces of arsenic oxides located close to the surface [3]. Finally, measurements on layered GaAs/AlAs structures provide new insights into the microscopic dynamics of the LAO process [4].

[1] G. Mori, M. Lazzarino, D. Ercolani, G. Biasiol, and L. Sorba: *Magnetic field and temperature dependence of an atomic force microscope-defined quantum point contact,* J. Vac. Sci. Technol. B **22** (2004) 570.
[2] D. Ercolani, M. Lazzarino, G. Mori, B. Ressel, L. Sorba, A. Locatelli, S. Cherifi, A. Ballestrazzi, and S. Heun: *GaAs oxide desorption under extreme ultraviolet photon flux,* Adv. Funct. Mater., in press.
[3] G. Mori, S. Heun, D. Ercolani, M. Lazzarino, A. Locatelli, and L. Sorba: *Desorption dynamics of LAO-oxide nanostructures,* J. Appl. Phys., submitted.
[4] G. Mori, M. Lazzarino, D. Ercolani, G. Biasiol, L. Sorba, A. Locatelli, and S. Heun: *Evidence of material mixing during local anodic oxidation,* in preparation.