L-02 **Monday, 13.06., 15^{50} - 16^{30}**

Synchrotron based imaging and spectroscopy of nanostructures for electronics and photonics – growth, geometry and function

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Already today, the circuits in the chips driving our computers and mobile devices have reached the nanoscale. This development is only accelerating, and in the future nanoscale electronic and photonic components will be ubiquitous in consumer electronics, renewable energy devices, energy storage, LEDs and much more. Synchrotron based techniques are playing a significant role in the development of future electronics as it is possible to directly investigate many aspects of device growth, operation and structure that is not available by laboratory based techniques.

In this presentation three prominent examples will be given demonstrating the use of different synchrotron based techniques, often in combination with complementary lab based methods. All these methods will be available at the highest level at the next generation synchrotron [1] MAX IV currently under construction in Lund (inauguration 21st of June 2016), which will also briefly be introduced.

Firstly we present studies of free-standing III-V nanowires. These have the potential to become central components in future electronics and photonics with applications in IT, life-science and energy[2]. The atomic scale structure and morphology of semiconductor nanowire surfaces are central in determining both growth and function of the wires [3]. Using synchrotron based Spectroscopic Photo Emission and Low Energy Electron Microscopy (SPELEEM) we have characterized III-V nanowire surface chemistry and electronic properties, investigated ultra-thin dielectrics, native oxides and epitaxial shells [4-6]. Combining this with several types of Scanning Probe Microscopy a complete picture of surface chemistry, effects on bandbending and information on axial and radial doping is obtained [3,7-11]. We demonstrate a complete control of their surface chemistry and structure to the atomic scale can be obtained. We show how full III-V nanowire devices can be imaged in SPELEEM – the devices are specially designed to avoid image distortions and to enable display of clean surfaces.

Secondly we will discuss dynamic studies of surface chemistry and dynamics using SPELEEM and ambient pressure X-ray Photoelectron Spectroscopy (AP-XPS). Using *in situ* SPELEEM performed in real time, we explore the dynamics of micron-sized Ga self-propelled droplets on GaP(111). The motion of these droplets can be further manipulated using Au nanoparticles. We establish the equations of motion that can generally describe the Ga droplet dynamics and demonstrate how several nanoscale and atomic scale mechanisms act together to control the motion of the droplets [12,13]. We then go on to show how the chemistry of technologically important processes such as Atomic Layer Deposition (ALD) of HfO_2 can be directly investigated using AP-XPS. This gives us new insights into the growth processes and demonstrate that the simple picture of the ALD growth is not quite true when the process can be explored while it is happening.

Thirdly, we discuss nanofocused hard X-ray beams as nondestructive probes that uniquely allow direct measurements of the nanoscale strain distribution and composition inside the micrometer thick layered structures found in many electronic device architectures. While the method has generally been considered time consuming, we demonstrate that by special design of X-ray nanobeam diffraction experiment we can (in a single 2D scan with no sample rotation) measure the individual strain and composition profiles of many structures in an array of upright standing nanowires [14]. Additionally the use of the coherence of the X-ray beam allows for considerable gains in resolution without tightly focusing the X-ray beam. In the present case, we image complex nanowires for nanoLED fabrication and compare to theoretical simulations [14,15]. We then go on to discuss the use of the new highly coherent synchrotrons such as MAX IV for microscopy [16].

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