Atomic scale analysis of individual semiconductor impurities and nanostructures by STM

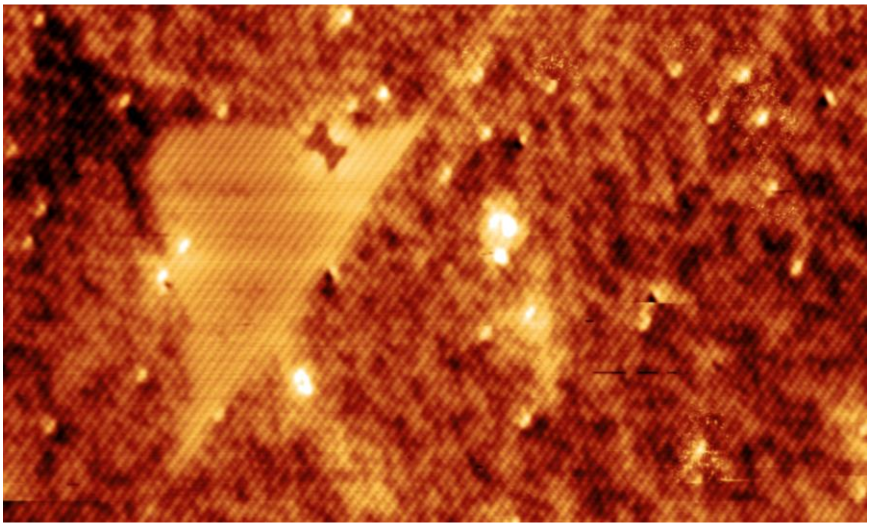
P.M. Koenraad

Department of Applied Physics, COBRA
Eindhoven University of Technology, the Netherlands

Scanning probe tools like Scanning Tunneling Microscopy (STM) are essential for the advancement of nanotechnology. Also in the field of semiconductor nanophysics our understanding has strongly progressed through scanning probe techniques like cross-sectional STM. In this technique a semiconductor sample is cleaved under ultra-high vacuum conditions where the cleaved facet is then imaged with an STM tip. In this manner we can obtain atomically resolved cross-sectional images of semiconductor nanostructures, as for instance shown in the figure below, or explore and manipulate the properties of single impurities in semiconductor host.

In this presentation I will discuss our recent work on imaging semiconductor quantum dots obtained by either the Stranski-Krastanov growth mode or droplet epitaxy. By combining the results obtained by cross-sectional STM with those obtained by Atom Probe Tomography we were able to reveal fascinating atomic scale details in full 3D in the growth mechanisms as well as the structural properties of quantum nanostructures .

In the second part of the presentation I will focus on our exploration of single (magnetic) impurities and discuss how we can control them individually. I will discuss how we can modify the charge and/or valence states of a single Mn or Fe impurity in GaAs and how we can control the configurational state of a single bi-stable Si atom in the surface of GaAs. This allowed us to build a single atom memory cell and a single atom photon detector. Experiments like this will pave the way for the emerging field of solotronics where a single impurity will be the active element in the device [1].



Atomically resolved cross-sectional STM image of a GaAs Quantum dot in AlGaAs grown by droplet epitaxy.

[1] P.M. Koenraad & M.E. Flatté, Nature Materials **10**, 91 (2011)