Single impurities in semiconductors studied by STM

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Single impurities play an increasingly important role in devices and fundamental physics. In the emerging field of solotronics [1], where a solitary dopant determines the optoelectronic functionality, many exciting successes have recently been obtained. We use a Scanning Tunneling Microscope (STM) to examine and manipulate single impurities close to a natural cleavage plane of the semiconductor host to unravel their properties that can be strongly affected by the semiconductor-vacuum interface.

Cross-sectional Scanning Tunneling Microscopy (X-STM) is a unique tool to address single impurities in a III/V semiconductor host. The nearby STM tip allows controlling the ionization state of single impurities and spatially resolving the shape of the wavefunction of a single hole or electron bound to an impurity atom. The X-STM topographic and spectroscopic measurements were performed at room temperature and low (4.2 K) temperature in UHV at the cleaved (110) surface of III/V semiconductor nanostructured materials.

In this presentation I will focus on recent results that we have obtained on bi-stable Si atoms in the outer most layer of GaAs. Si atoms in this outer most layer can occur in two different states: either a deep negatively charged ground state or a meta-stable shallow positively charged state. Their behavior is closely related to the well-known DX-center. I will discus how we can electronically and optically control this bi-stable defect and how we can study its switching dynamics. I will demonstrate how we can use a single Si atom as a memory element or photon switch.

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