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STM manipulation and measurement of charged species in semiconductors[1]

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The scaling of transistors to nanometer dimensions requires more precise control of individual dopants in semiconductor nanostructures, as statistical fluctuations in dopant distributions can significantly impact device performance. Proposals for next-generation quantum- and spin-based electronics also rely on the tuning of the charge, spin and interactions of dopant atoms with local electric fields. Using a scanning tunneling microscope (STM), we demonstrate how to control the binding energy and ionization state of individual acceptors in p- GaAs [1]. Charged species such as native dopants, vacancies and adatoms directly influence the acceptor binding energy via the Coulomb interaction. In addition, a combination of defect- and tip-induced band bending can be used to remotely tune the acceptors' ionization state. We find that by applying voltage pulses with the STM tip, charged vacancies and adatoms can be positioned on the surface. These experiments suggest a new and direct method for quantifying the charge of adsorbates (e.g. adatoms or molecules) as well as defects (e.g. vacancies, antisites, interstitials) at semiconductor surfaces.

[1] D.H. Lee and J.A. Gupta (submitted)

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