Hydrogen Passivation of N:GaAs Studied by Cross-Sectional Scanning Tunneling Microscopy

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Introduction of a few percent N in GaAs causes a large reduction of its bandgap. This effect can be passivated by post-growth introduction of hydrogen into the material, the bandgap will then return to the value of N-free GaAs. Hydrogen is incorporated in the material in the form of two different NH-complexes, N-2H and N-3H. N-2H is responsible for the restoration of the bandgap, while N-3H influences the strain in the material. These NH-complexes can be removed again by annealing the samples either above 250C, to remove the N-3H, or 330C, to remove the N-2H. The complexes can also be removed at a local scale, either by laser irradiation or scanning near-field microscopy. This completely reverses the effects of the passivation, which allows for the creation of nano-structures such as quantum dots and nano-wires. With cross-sectional scanning tunneling microscopy we have been able to directly study the NH-complexes at the atomic scale for the first time. Cross-sectional scanning tunneling microscopy was performed on various hydrogen passivated N:GaAs samples. We classified three features, two of which have never been seen before on non-passivated N:GaAs. The first feature is a N atom adsorbed on the surface. The other two are related to NH-complexes, which can be switched or modified by local voltage pulses. We discuss a number of possible lattice configurations of these features based on crystal-symmetry arguments.