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A surface-driven approach to the synthesis of basic building blocks for the design of complex Si-Ge-Mn nanostructures

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The combination of Silicon and Germanium with Manganese is highly desirable for the development of novel spintronics devices. We will describe a surface-driven approach to the tailored synthesis of basic building blocks for the design of complex Si-Ge-Mn nanostructures. The goals are to incorporate Mn as delta-doped layers in a Si matrix, and to magnetically dope Ge-quantum dots. These processes are studied with STM and photoelectron spectroscopy. The Si(100)(2x1) surface functions as a template and Mn-nanowires are formed which run perpendicular to the Si-dimer rows. The bonding sites of the Mn-adatoms, the wire length and spatial distribution are interpreted within the framework of recent theoretical predictions. The bonding of Mn-adatoms changes with temperature: at 500 K the adatoms move into sub-surface sites, higher temperatures initiate silicide formation, which is controlled by the Si- surface atom mobility. In a next step we deposited a Ge-overlayer on the Mn-wires, and used voltage dependent STM analysis to separate the Ge and Mn contributions. In the low-adatom-mobility regime the Mn-wires are preserved. The low temperature growth therefore offers a pathway to create buried nanostructures in controlled manner. The formation of Mn-doped Ge-quantum dots is approached by the deposition of Mn on the Ge-QDs at 273 K. On both surfaces, the Ge(100) wetting layer and the Ge (105) facet of the QDs, the Mn adatoms form nanoclusters. On the Ge(105) facet the flat clusters are aligned with respect to the reconstruction, and the wetting layer surface is considerably roughenend. Annealing of the surface structures to initiate a diffusion of Mn into the Ge-QD bulk is investigated as a means to achieve local doping. However, the annealing process leads to a highly complex response which is extremely sensitive to temperature. While these processes are by no means currently understood, we will offer a first qualitative interpretation of the observed reactions.