Mn Manipulation by STM on a GaAs (110) Surface

D.Grossi, P.M.Koenraad
Department of Applied Physics, Eindhoven University of Technology,
P.O. 513, 5600 MB, Eindhoven, The Netherlands

Abstract

Scanning Tunneling Microscopy is a technique that allows to probe the topography and the electronic properties of a surface with an atomic resolution. In these experiments however we used this extreme resolution to manipulate, move and embbed single atoms on a semiconductor surface [1]. Mn atoms have been successfully deposited by evaporation on a Zn doped GaAs substrate. The individual steps of the manipulation experiment are shown in figure 1 In future work we will exploit the possibility to move and embed single Mn adatoms to create structures of dopants. For instance we want to position two Mn close to a subsurface dopant and study its role in mediating the Mn-Mn interaction.

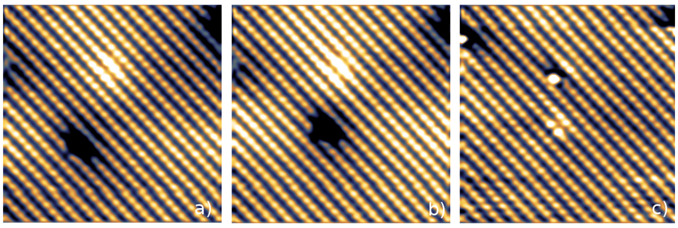

Figure 1: STM images taken at $V = -2V$ and $I = 70pA$ on the same area of 10x10 nm. Mn adatoms give rise to a dark contrast, as in (a). Placing the tip close to the Mn adatom and applying a voltage pulse, a jump of the adatom to a neighboring site is induced (b). When the tip is positioned at the center the dopant instead, the Mn can be embedded in the surface layer, while a Ga atom is pushed out [1]. This is shown in (c), where the bright dumbbell feature, typical for Mn in the surface layer, can be observed and the small bright feature somewhat above the center of the image corresponds to the Ga adatom on the surface.

In some atom manipulation experiment the Mn adatom, instead of moving after a pulse, has been transferred from the GaAs surface to the STM tungsten tip. The process is shown in figure 2. Since Mn is a magnetic atom this process offers the possibility to perform spin polarized measurements even with a tungsten tip, simply by picking up a Mn adatom [2]. With this approach the magnetic properties of surface and doping atoms embedded in this layer can be investigated . A deeper investigation is however required to understand the condition under which this attachment process is favored over the adatom movement by jump to the nearest neighbor sites.

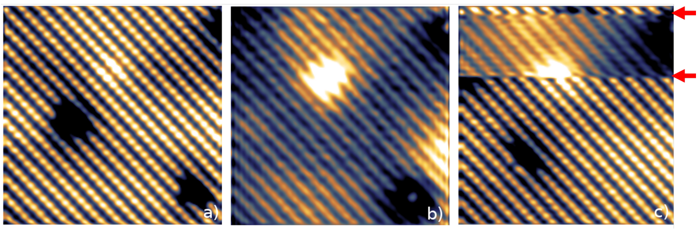

Figure 2: STM images of the adatom transfer process, taken at $V = -2V$ and $I = 70pA$. In figure (a) there are two Mn adatom on the surface (dark contrast). In figure (b) an image of the surface after a voltage pulse on the top Mn is shown. The effect of the pulse is the transfer of the adatom from the sample to the tip, which cause the change in contrast and resolution between image (a) and (b). In figure (c) is shown that the process of transferring a Mn adatom to the tip is reversible and controllable; the arrows indicate the line in which a pulse was applied.

[1] D. Kitchen, A. Richardella, J.-M. Tang, M. E. Flatté, and A. Yazdani, Nature pp. 436–9 (2006).
[2] C. F. Hirjibehedin, C. P. Lutz, and A. J. Heinrich, Science **312**, 1021 (2006).