Writing Nanoscale Surface Structures

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Nanoscale structuring by electron beam induced deposition has been performed, making structures with sub 10 nm dimensions. In experiments where a surface is irradiated with an electron beam, the beam can induce direct deposition of material from the surroundings[1]. It is also known that surface modification takes place under electron irradiation and selective epitaxial growth is stimulated in the areas irradiated by the electron beam.[2,3]

In a Scanning Transmission Electron Microscope (STEM), a spot of electrons as small as 0.2 nm can be made. With this spot, it is possible to deposit structures with typical dimensions of 3 nm[1]. In this way we have been able to deposit amorphous carbon lines as narrow as 4.3 nm[1] and pillars with a FWHM in the range of 5 to 10 nm wide, see figure 1. We aim to make metallic structures on a scale of a few nanometers by irradiating samples where an organo-metallic gas is adsorbed. This has been shown for structures of several tens of nanometers [4].

We are developing an electron microscope such that deposition can be performed at the nanoscale. The deposition process itself at the nanoscale is a slow process. To reduce time needed to deposit complex structures, we are designing an electron microscope with an array of 10x10 beams, each beam with a size at the sample of no more than 1 nm. The whole array of beams is scanned and each of the beams can be switched on or off independently. Thus in one scan 100 different, arbitrary patterns can be written.

Furthermore, we aim to develop a thorough understanding of the deposition process itself. We have explained why deposits of amorphous carbon as small as 2nm can be grown in electron beam induced deposition[1].
If the deposition of material is from an organo-metallic material, the structures consist of small metallic crystallites embedded in an amorphous carbon matrix. Solid metal structures can also be formed[5] by properly choosing deposition parameters, the carbon matrix can be removed form the deposit and the metallic structures are left behind. However, if small crystallites are formed during deposition, the metallic lines do not form solid wires. We are working to understand which process parameters play a role in the formation of the nano-crystallites. Understanding of the deposition process enables us to control shape and material composition of the deposited nanostructures.

In conclusion, we aim to develop equipment and knowledge that enables us to make structures of well designed, arbitrary shape and composition on the nanoscale.

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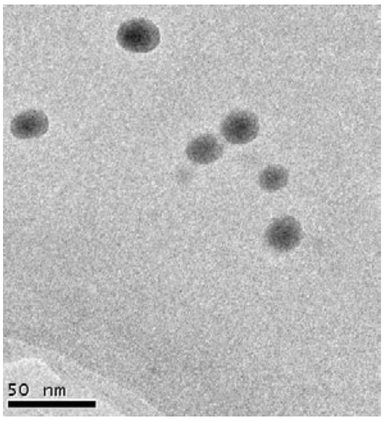

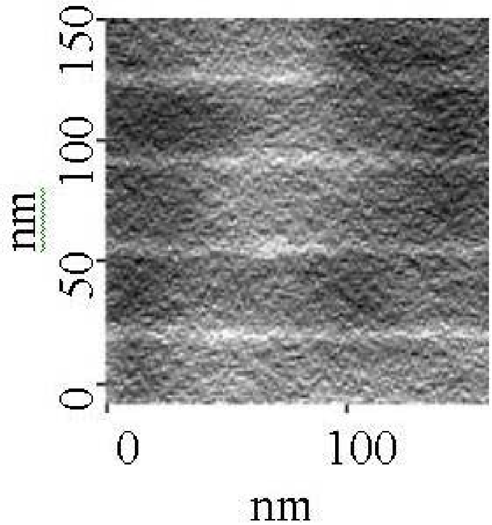

Figure 1 : Nanoscale pillars grown on carbon foil. The shown pillars have a width of 5 to 10 nm. Left is a 'top' view of the pillars. Right a series of 4.3 nm wide lines of amorphous carbon.

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