Dynamic Shadow Mask Technique: Device Fabrication and Characterization in UHV

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The dynamic shadow mask technique (or dynamic nano-stenciling) uses a fine perforated shadow mask which is moved with high precision in close proximity to the substrate during exposure to a molecular beam. The mask is, for example, a perforated silicon nitride membrane and the material source can be a thermal evaporator. Using this principle in ultra high vacuum (UHV) allows the fabrication of clean structures, avoiding the use of resist and the contamination with chemicals and air. The principle is very flexible as it can be applied for patterning of various materials (metals, insulators, (in)organic semiconductors) on any kind of substrate (including non-flat or porous surfaces or fragile objects).

This contribution will focus on the fabrication of complex structures and devices. Devices, which consist of different materials, can be fabricated with a small number of process steps entirely in UHV (Fig. 1ab). The dynamic shadow mask technique is an ideal fabrication method for fundamental studies and for testing new device ideas. Additionally the technique can easily be combined with other methods, for example to add electrical contacts or functional elements on prefabricated nano-objects (Fig. 2).

The dynamic shadow mask set-up is similar to a scanning probe microscope; therefore the same components can easily be used for in-situ characterization of the structures, just by replacing the mask with an AFM cantilever or an electrical two tip probe (Fig. 1bc, Fig. 3).

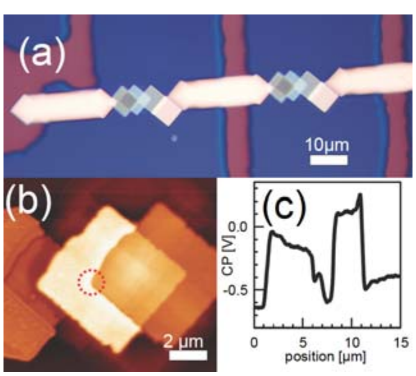

Figure 1. (a) Optical image of two devices. The large connection lines were fabricated with a different shadow mask. (b) Diode device formed in the overlapping region of two squares. The electrode overlap area (marked with a circle) is about 200 nm wide. Note that the active device area can be fabricated much smaller than the mask aperture because it depends mainly from the positioning accuracy. (nc-AFM image recorded in-situ). (c) Contact potential line scan measured on a similar device as shown in (b).

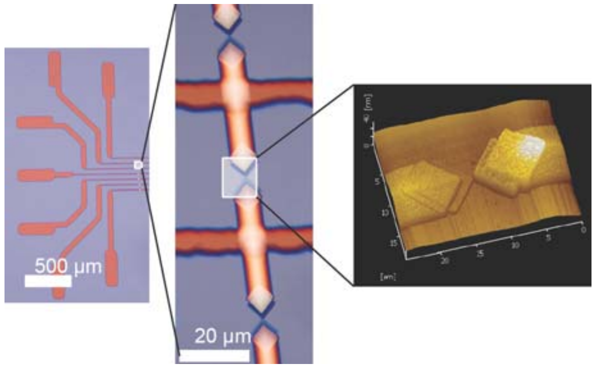

Figure 2. Fabrication method for gap (or point contact) structures. All elements shown are fabricated in UHV, using two different masks. (This type of structure is as well used for connecting prefabricated nano-objects.)

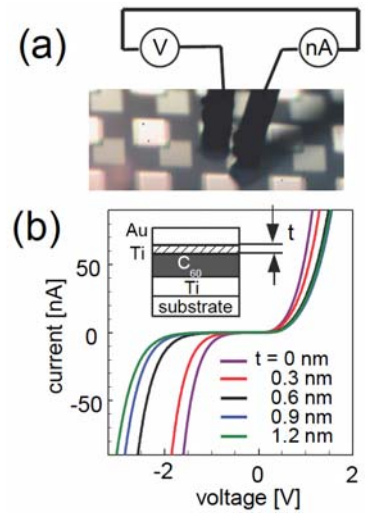

Figure 3. In-situ electrical transport measurements on diode array. When fabricating the array, a second moving shadow mask was used to create an inhomogeneous exposure to the molecular beam: The individual devices (in the overlapping corners of the squares) have a well defined variation in one parameter (*combinatorial device fabrication*). A small part of a device array is shown in (a). The thickness variation of one film leads to changes in the I-V curves (b).

References:

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