Focused electron-beam-induced deposition of 3 nm dots in a scanning electron microscope

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Electron-beam-induced deposition[1] (EBID) allows the rapid creation of three-dimensional nano-devices directly within a scanning electron microscope (SEM). The deposited material depends on the precursor chosen, for instance tungsten material can be deposited from the precursor tungsten hexacarbonyl. The decomposition of the gaseous precursor is caused by the interaction of an electron beam with a solid substrate. Typically the dimensions of the fabricated structure are in the range 20 nm to several µm; with further work nanowires and nanodots with single-digit nm lateral size can be made.[2,3,4]

We present our efforts in performing high-resolution EBID in an SEM. Previous work in our group [5,6] resulted in 0.7 nm nanodots being created by EBID using a STEM.[7] However it is also desirable to demonstrate high resolution EBID in an SEM since the instrument is more widespread and easier to use. In principle, in a modern SEM with a probe size below 1 nm, sub-3 nm small nanodots can be similarly achieved.[8,9] Until now the record was 3.5 nm, measured indirectly by an AFM and correcting for the tip shape.[10] We have achieved a nanodot with a full width half maximum (FWHM) of 2.8 ± 0.3 nm, measured directly with the dark field transmission signal in the same SEM soon after deposition (Figure 1).

We discuss the current limitations of the experiments: the detectability of the just-performed deposit, proximity effects during growth and local inhomogeneities in substrate secondary electron yield. We are confident that even smaller nanodots can be deposited in the SEM provided these issues can be addressed.

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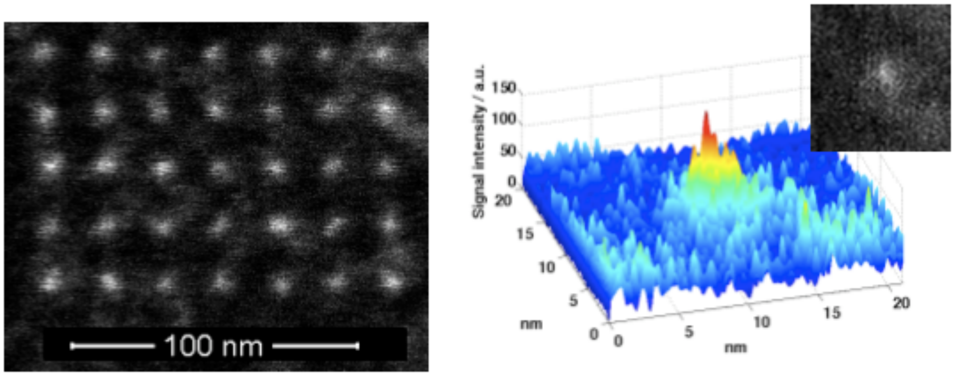

Figure 1: (left) Dark field transmission image of a nanodot array on a thin carbon membrane. (right) 2- and 3-dimensional image of a nanodot with FWHM 2.8 ± 0.3 nm. The FWHM quoted here is obtained by averaging four measurements in different directions across the same nanodot.