Functionalization of focused electron beam induced deposits by directed self-assembly

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Combining cutting-edge lithography with molecular self-assembly processes can lead to unique and otherwise inaccessible materials for future nanotechnological applications [1]. Sub-micrometer patterning of functional molecules such as molecular motors, molecular switches, etc. can currently be done with for instance scanning electrochemical microscopy [2], dip-pen lithography [3] or electron beam lithography [4]. We present a new approach of using focused electron beam induced deposition (FEBID) [5] to create smaller SiO_2 patterns in a single step. We demonstrate that these patterns can be readily functionalized, for instance with fluorescent molecules (see Fig. 1).

Patterning is performed on a Tescan Lyra dual beam instrument. The substrate is silicon, the precursor is 2, 4, 6, 8, 10-pentamethyl-cyclopenta-siloxane, the beam current is about 600pA and the beam size is about 3.5 nm. The SiO_2 is activated with piranha solution, the linker molecule is (3-aminopropyl)triethoxysilane and the fluorophore is fluoroscein isothiocyanate.

Fig. 2a shows an SiO_2 pattern of 100x100 nm squares as written in the SEM. Inspection with the optical microscope using white light (Fig. 2b) and 488 nm light (Fig. 2c) shows that the squares can be functionalized. Fig. 3a shows that branching of the deposit can occur during pillar growth of the SiO_2 deposit. This is consistent with other experiments, often attributed to charging. Fig. 3c shows that the pillars can also be functionalized. The smallest feature size that can be successfully functionalized is currently 80 nm.

We will present the results of our efforts to increase the resolution to 20 nm for functionalized features and to eliminate the non-linear growth.

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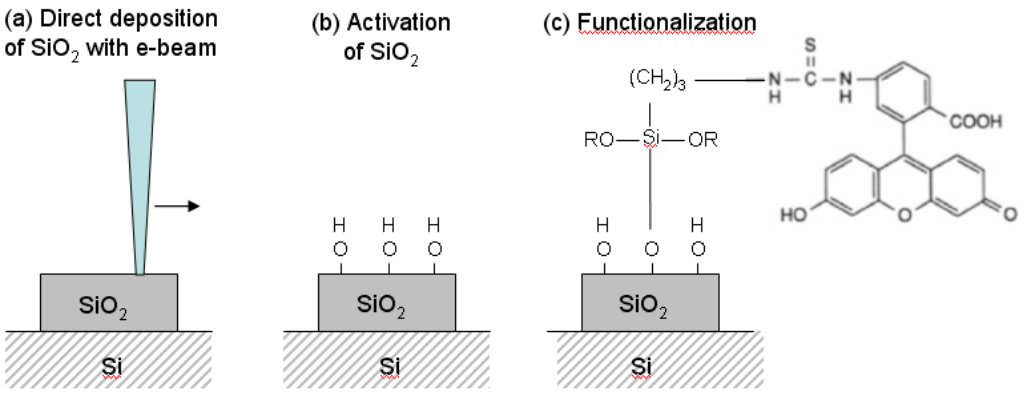

Figure 1. (a) An SiO_2 pattern is written in the SEM using FEBID. This pattern is activated (b) and functionalized (c) with fluorescein isothiocyanate.

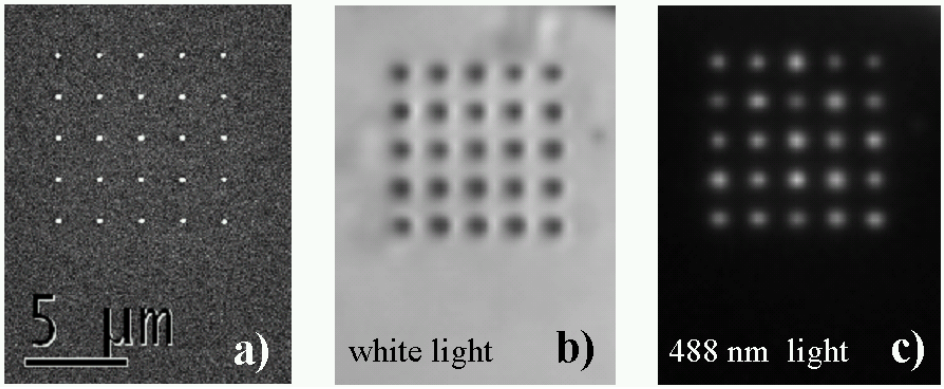

Figure 2. (a) 100x100 nm squares, written in the scanning electron microscope. (b) Same pattern as in (a), now observed in the optical microscope with white light after activation and functionalization. (c) Same pattern as in (b), now observed with 488 nm light.

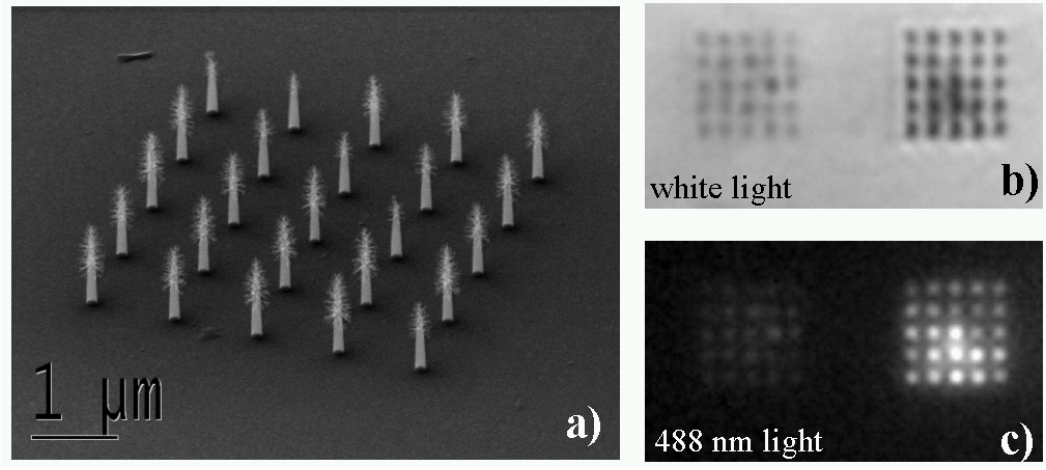

Figure 3. (a) SiO_2 pillars deposited from in the SEM with FEBID. Branching of the deposits is observed, an effect that is often attributed to charging. (b) The array on the right is the same array as in (a), now observed in the optical microscope with white light after activation and functionalization. (c) Same pattern as in (b), now observed with 488 nm light.