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Focused Electron Beam Induced Deposition of 1,1-dichloro-1-silacyclohexane, silacyclohexane and 1,3,5-trisilacyclohexane; preliminary study on the role of low energy secondary electrons in the deposition process.

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Synopsis To study the potential role of low energy secondary electrons in focused electron beam induced deposition (FEBID) we have studied FEBID using 1,1-dichloro-1-silacyclohexane, silacyclohexane and 1,3,5-trisilacyclohexane. While the first of these compounds shows appreciable cross sections for dissociative electron attachment (DEA) in the gas phase, DEA is not observed for the latter two. Dissociative ionization, on the other hand is a fairly efficient decomposition path for all three compounds. The performance of these compounds in FEBID is compared with their decomposition through low energy electrons in the gas phase and discussed in context to the role of DEA and DI in FEBID.

Focused electron beam induced deposition (FEBID) is a direct writing technique suitable for the fabrication of three dimensional nanoscale structures. In this technique a tightly focused high-energy electron beam impinges on a surface under a constant stream of precursor molecules. Ideally these decompose through electron-induced processes leaving a well defined deposit, which spatial extension is confined to the focal with of the high-energy electron beam. However, through elastic and inelastic (ionizing) scattering of the high-energy electron beam, large amount of secondary electrons (SEs) are produced outside the focal point of the primary beam. These SEs are capable to dissociate precursor molecules through dissociative electron attachment (DEA), dissociative ionization (DI), neutral dissociation (ND) and dipolar dissociation (DD) - processes that have distinctly different characteristics with regards to the products formed and their energy dependency. Recent gas phase studies [1-3] showed that commonly used precursor molecules can have considerable DEA and DI cross sections and that these processes may thus play an important role in FEBID. Especially these processes are potentially responsible for broadening of the deposit beyond the focal width of the primary beam.

In the current contribution we put effort into comparing the relative role of DEA and DI in FEBID by comparing the performance of 1,1-dichloro-1-silacyclohexane (DCSCH), silacyclohexane (SCH) and 1,3,5-trisilacyclohexane (TSCH) in FEBID with gas phase, experiments where these molecules all decompose through DI while DEA is only observed for DCSCH [3].

For comparison we grew series of pillars using DCSCH and TSCH with increasing electron beam exposure time. The base diameter of the pillars grown with TSCH is saturating much sooner (at ~97nm) than those of DCSCH (at 160nm). Similarly the diameter of neighboring pillars, in close proximity to growing pillars, is found to be stronger influenced (broadened) in DCSCH. Figure 1 shows this effect for arrays of nanopillars from SCH and DCSC, deposited from top to bottom and left to right. While the first and last grown pillars for SCH shows more or less same diameter, there is a considerable difference for DCSCH.

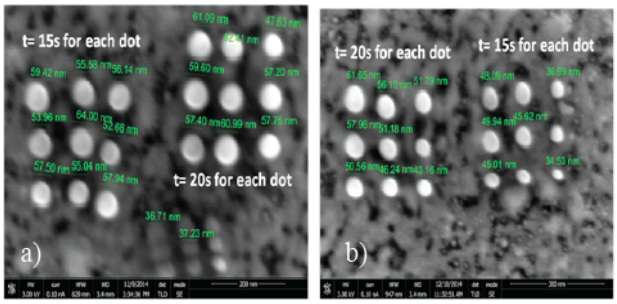

Figure 1. Array of nanopillars deposited with a) silacyclohexane and b) 1,1-dichloro-1-silacyclohexane.

In the current contribution we discuss these FEBID results in context to the efficiency of DI and DEA to these compounds in the gas phase.

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