Effect of gaseous additives on Electron Beam Induced Deposition

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The direct deposition of materials with the focused electron beam has been recognized as a versatile nanostructuring method, which does neither require masks nor resist layers. This method has been demonstrated to provide real 3-D structures [1,2] as well as ultrasmall features in the range of a single nanometer [3]. The method of electron beam induced deposition (EBID) is based on the chemical vapor deposition of material as a result of an electron beam induced surface reaction of the precursor molecule. Depending on the type of precursor molecule either metals such as W, Pt, Au, Fe or dielectrics such as silicon oxide have been deposited. However, the purity and the deposition rater are challenging issues.

In this work we have investigated the beneficial effects of gaseous additives to the precursor gas. With silicon oxide deposition as additive molecular oxygen has been added to the siloxane precursor, and with iron deposition as additive molecular hydrogen has been added. We have studied the effects of these additives on the material purity, on the deposition rate and on the geometric shape of the depositions. With addition of oxygen to a siloxane precursor not only the deposition efficiency, but also the material purity was significantly increased. With the deposition of iron from Fe(CO)5 the addition of hydrogen gas obstructed the radial growth and led to different geometries.

The addition of a reactive gas species to the primary precursor molecule has the potential to significantly influence the deposited material. This approach has been demonstrated to have a powerful potential for the improvement of EBID-processes.

[1] Liu ZQ; Mitsuishi K; Furuya K, “Three-dimensional nanofabrication by electron-beam-induced deposition using 200-keV electrons in scanning transmission electron microscope”, Applied Physics A80(7), 1437 (2005)

[2] Hoffmann P; Bret T; Utke I; Abourida M; Doppelt P, “Electron range effects in focused electron beam induced deposition of 3D nanostructures”, Microelectronic Engineering 83(4-9), 1482 (2006)

[3] Van Dorp W.F., Hagen C.W., Crozier P.A., van Someren B., Kruit P., “One nanometer structure fabrication using electron beam induced deposition”, Microelectronic Engineering 83 (4-9), 1468 (2006)

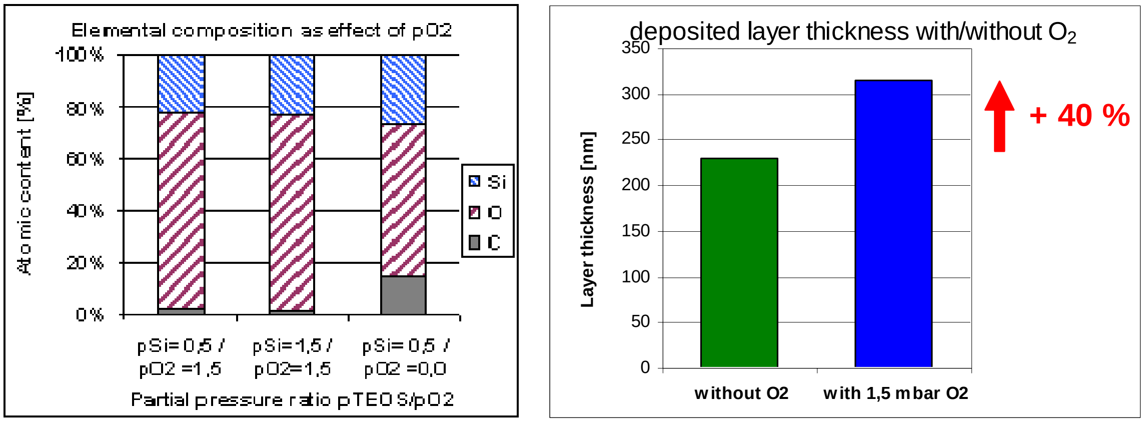
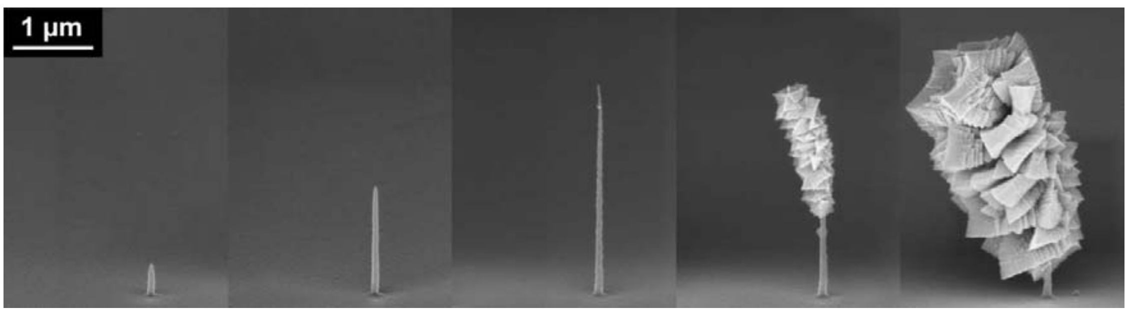
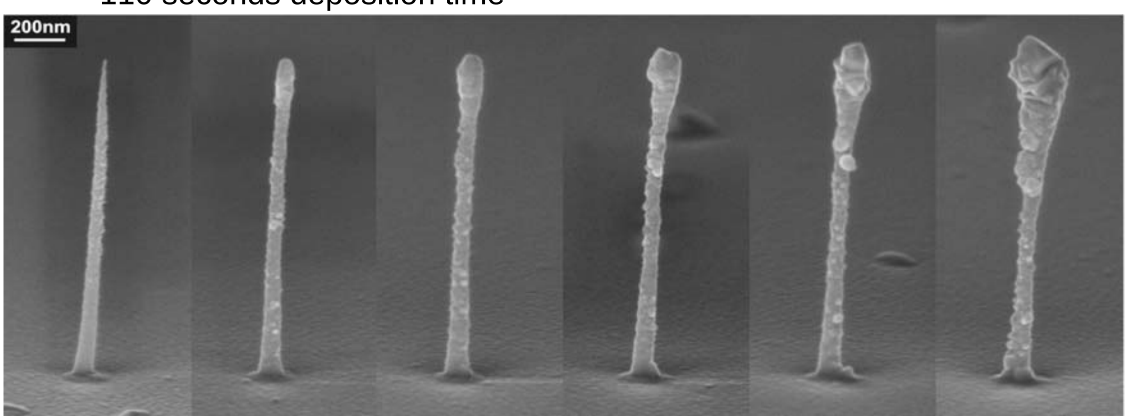


Fig. 1 Influence of O2 Addition on the deposition efficiency and on the material purity of EBID of silicon dioxide



(a) iron structures deposited without hydrogen after 10, 30, 60, 75 and 110 seconds deposition time



(b) iron structures deposited with addition of hydrogen after 30, 60, 90, 120, 240 and 360 seconds deposition time

Fig. 2 Influence of H2 Addition on the deposition efficiency EBID of iron