



Electron-induced and thermal surface reactions of iron precursors for FEBID

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Focused electron beam induced deposition (FEBID) is a state-of-the-art tool for fabrication of nanoscale materials and devices [1]. In FEBID, volatile metal-containing precursor molecules are dosed via a gas-injection system onto a surface where they are decomposed by a tightly focused electron beam. In the ideal case, the electron-driven fragmentation of the precursor is the decisive step in deposit formation. For a precise control of the deposit composition, this reaction should leave only the metal on the surface. Moreover, to achieve optimal control of the deposit shape by the electron beam, the adsorbed precursors should not react with the underlying surface but remain intact until they are dissociated by an electron. In reality, though, thermal surface reactions akin to chemical vapor deposition (CVD) can contribute to deposit growth and lead to deviations from the intended deposit shape [2]. Strategies to suppress unwanted thermal deposition are therefore needed to develop optimized FEBID processes, calling for a fundamental understanding of thermal reactions of precursor molecules on the surfaces of FEBID deposits.

Fe(CO)₅ is an example of a FEBID precursor that decomposes thermally on various surfaces [3]. While the resulting autocatalytic growth leads to deposits with high purity [3], it can also distort the deposit shapes as reported for the fabrication of nanoscale pillars [4]. Therefore, we have investigated strategies to suppress autocatalytic growth of Fe from Fe(CO)₅. For instance, NH₃ as a process gas can inhibit the thermal decomposition of Fe(CO)₅ on an Fe deposit prepared by electron-induced deposition using the same precursor [5]. Similarly, the novel heteroleptic precursors Fe(CO)₄MA and Fe(CO)₄A also offer the perspective to control thermal chemistry in FEBID without significant impact on the deposit composition [6,7]. To this end, we have investigated the electron-induced and thermal reactions of Fe(CO)₄MA and Fe(CO)₄A as compared to Fe(CO)₅ using reflection absorption infrared spectroscopy (RAIRS). The study revealed that Fe(CO)₄A and Fe(CO)₄MA undergo dissociative adsorption on the surface of an Fe deposit produced by electron irradiation of adsorbed Fe(CO)₅. The resulting chemisorbed layer suppresses autocatalytic growth of Fe from Fe(CO)₄A and Fe(CO)₄MA and also from Fe(CO)₅ [8]. RAIRS was furthermore used to compare the reactions of the different precursors during electron beam induced deposition at room temperature and under cryogenic conditions [8]. This contribution presents an overview of our results and discusses their implications for FEBID processes.

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