



Chemistry of deposit formation in FEBID studied by reflection absorption infrared spectroscopy, desorption experiments and Auger electron spectroscopy

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The formation of a deposit during focused electron beam induced deposition (FEBID) depends on the interaction of precursor molecules with the underlying surface and their electron-induced reactions. However, contrary to an assumption expressed years ago from a valuable member of the FEBID community [1], knowledge about surface interactions still exists for only few of the precursor molecules commonly used in FEBID. Furthermore, the adsorption mode on an actual deposit produced by FEBID has hardly ever been investigated. For instance, many surface science studies have addressed the adsorption of $\text{Fe}(\text{CO})_5$ on diverse single crystal metal surfaces [2], but comparable work has not been reported for $\text{Co}(\text{CO})_3\text{NO}$. Regarding the electron-induced chemistry that underlies FEBID, surface science studies have typically focused on multilayer precursor adsorbates which need to be prepared and held at cryogenic temperatures during irradiation. Using this approach, much valuable insight has been gained [3-5]. However, the actual FEBID process is usually performed at room temperature. Here, only submonolayer to monolayer precursor quantities reside on the surface and additional thermal reactions may be activated [6].

In order to extend surface science studies performed in ultrahigh vacuum to model the deposition processes more realistically, we have established an approach that mimics electron beam induced deposition both at room temperature (EBID) and under cryogenic conditions (cryo-EBID) [7,8]. We refer to these processes as EBID because a defocused electron gun is used for irradiation of the entire surface to detect reaction products with optimal sensitivity. The inherent chemical processes are investigated by reflection absorption infrared spectroscopy (RAIRS), desorption experiments (ESD and TDS), and Auger electron spectroscopy (AES). In EBID experiments, the precursor vapour is dosed during electron irradiation onto the surface held at room temperature. For cryo-EBID, the precursors are dosed onto the liquid nitrogen-cooled surface producing a multilayer adsorbate which is then irradiated. In addition, the chemical processes during thermal surface reactions on previous deposits produced by EBID including autocatalytic growth are monitored. Herein, we present new insight for $\text{Co}(\text{CO})_3\text{NO}$ obtained by this approach and discuss differences between EBID and cryo-EBID.

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References

- [1] Confidential source but you may ask the poster presenter for the anecdote.
- [2] L. Barnewitz, H. Boeckers, A. Chaudhary, L. McElwee-White, P. Swiderek, *Phys. Chem. Chem. Phys.* 28, 9745-9761 (2026).
- [3] W.G. Carden, H. Lu, J.A. Spencer, D.H. Fairbrother, L. McElwee-White, *MRS Commun.* 8, 343-357 (2018).
- [4] S. Barth, M. Huth, F. Jungwirth, *J. Mater. Chem. C* 8, 15884-15919 (2020).
- [5] J.-C. Yu, M. K. Abdel-Rahman, D. H. Fairbrother, L. McElwee-White, *ACS Appl. Mater. Interfaces* 13, 48333-48348 (2021).
- [6] I. Utke, P. Swiderek, K. Höflich, K. Madajski, J. Jurczyk, P. Martinović, I.B. Szymańska, *Coord. Chem. Rev.* 458, 213851 (2022).
- [7] H. Boeckers, A. Chaudhary, P. Martinović, A. V. Walker, L. McElwee-White, P. Swiderek, *Beilstein J. Nanotechnol.* 15, 500-516 (2024).
- [8] L. Barnewitz, H. Boeckers, A. Chaudhary, N. Kumar, L. McElwee-White, P. Swiderek, to be published.

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