

Electron beam seeding as a new tool for area-selective deposition of gold

Katja Höflich,^{*a}

^a *Ferdinand-Braun-Institut (FBH), Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany*

Gold is a key metal in microelectronics: its low resistivity, resistance to electromigration and chemical inertness render it an excellent choice for stable and reliable electrical contacts. Chemical vapor deposition (CVD) is a technologically significant route to gold contacts and other metallic functional structures. It relies on the thermal decomposition of gaseous precursor molecules: those reaching the surface decompose and leave their central metal atom behind. When decomposition is kinetically or thermodynamically favored on some surfaces over others, the resulting difference in reaction rates can be exploited for area-selective deposition.

This work presents a novel maskless patterning technique for area-selective CVD of gold [1]; Fig. 1 shows the process schematically. A focused electron beam locally decomposes the metal-organic precursor $\text{Au}(\text{acac})\text{Me}_2$ [2], creating an autocatalytically active seed layer for subsequent CVD with the same precursor. The seeding can be integrated within the same CVD cycle, avoiding cleanroom lithography. It operates at only 80 °C, over 200 K below standard CVD temperatures for this precursor, thereby reducing the thermal load on the specimen. Because electron-beam seeding works on any even moderately conductive surface, it imposes few constraints on device design. We demonstrate this with vertical nanostructures of high aspect ratio (around 40:1 and above). Written with a focused electron beam and the same precursor, these nanopillars carry catalytically active nuclei on their surface. These pillar growth experiments also allow, for the first time, a precise determination of the local temperature rise induced by electron-beam writing of nanostructures.

In summary, this work presents a new, technologically powerful and easy-to-implement approach to area-selective gold deposition. Due to the low temperature required, this technique is highly suitable for processing heat-sensitive polymer substrates, such as those used in flexible electronics and flexible solar cells. In addition, the maskless direct-write seeding also works on 3D architectures, offering the potential to fabricate nanostructures or localized electrical contacts on intricate 3D devices.

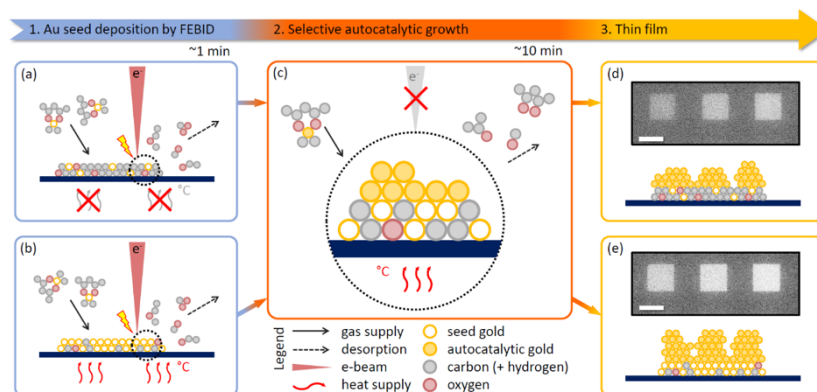


Figure 1. Area-selective gold growth by electron beam seeding a) & d) at room temperature (30 °C) or b) & c) at elevated substrate temperatures. c) After seeding the precursor is decomposed at the deposited Au nuclei without further electron-beam assistance for both. Scale bars represent 2 μm .

Acknowledgements

The authors acknowledge funding through the SNF-DFG WEAVE project, no. 579668301 (ebeam).

References

- [1] A. Tsarapkin, K. Maćkosz, C. S. Jureddy, I. Utke, and K. Höflich, "Area-Selective Chemical Vapor Deposition of Gold by Electron Beam Seeding," *Adv. Mater.*, vol. 36, p. 2313571, 2024.
- [2] I. Utke, P. Swiderek, K. Höflich et al., "Coordination and organometallic precursors of group 10 and 11: Focused electron beam induced deposition of metals and insight gained from chemical vapour deposition, atomic layer deposition, and fundamental surface and gas phase studies," *Coord. Chem. Rev.*, vol. 458, p. 213851, 2022.

* Corresponding author: katja.hoeflich@fbh-berlin.de