Creating free-standing nanostructures with plasmonic properties via Focused Electron Beam Induced Deposition

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Over the past decades, significant interest was directed towards the optical properties of nanoscale structures. As they are highly sensitive to slight changes in material, geometry, size and arrangement, controlling these aspects in every detail allows to tailor their plasmonic response according to the targeted operation and opens up access to a multitude of applications in research and development. With miniaturization reaching its limits, expanding the nanostructures into the third dimension could give access to horizontal and vertical mode coupling, reduce substrate damping, increase device performances and allow for the investigation of novel optical effects. Herein, we present how Focused Electron Beam Induced Deposition (FEBID), a 3D manufacturing technique capable of printing nanostructures with feature sizes down to around 10 nm, can be applied to fabricate and tune the plasmonic properties of planar and free-standing gold nanostructures.[1] Therefore, planar gold nanowires as well as free-standing nanotips of varying geometries are printed and purified with a focused electron beam and their plasmonic response investigated through STEM-EELS mapping measurements. Corresponding plasmon simulations provide additional backing to our experimental discoveries, displaying excellent agreement (see Figure 1). This study lays the foundation for on-demand spectral tuning of the plasmonic response in 3D systems through upfront modeling and design of tailored nanostructures, thereby unlocking opportunities for innovative plasmonic applications in 3D space.

Graphic:

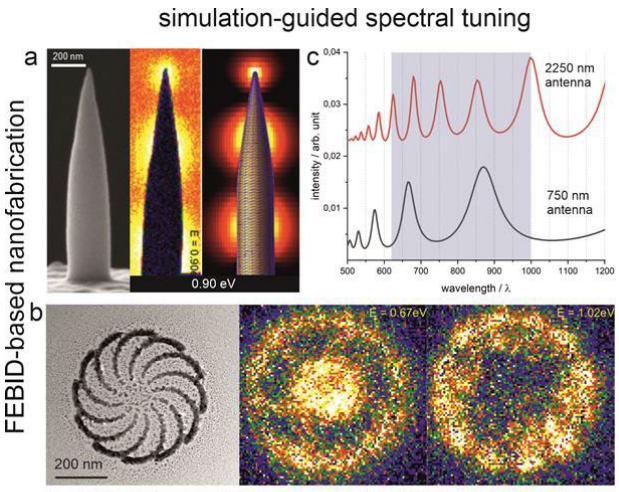

Figure 1: Free-standing nanotip **(a)** and planar spiral structure **(b)** fabricated with FEBID and purified via electron beam irradiation in water vapor atmosphere along with experimental and simulated EELS maps at selected energies. **(c)** Spectral tuning is exemplarily shown for the free-standing nanotip exhibiting a height of either 2250 nm or 750 nm.[1]

Keywords:

Nanoplasmonics, Spectral Tuning, Additive Manufacturing,

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[1] V. Reisecker, D. Kuhness, G. Haberfehlner, M. Brugger-Hatzl, R. Winkler, A. Weitzer, D. Loibner, M. Dienstleder, G. Kothleitner, H. Plank, Adv. Funct. Mater. 2023.