

Electron-beam 3D nanoprinting: open-source patterning and functional magnetic nanoarchitectures

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Focused electron beam induced deposition (FEBID) combines nanoscale resolution with resist-free, direct-write fabrication of free-standing three-dimensional structures. A central challenge is translating an arbitrary 3D design into electron-beam exposure patterns that produce the intended geometry across different materials and instruments. To address this, we have developed f3ast, a layer-by-layer nanoprinting platform that slices standard 3D design files and uses a continuum description of FEBID growth to generate the corresponding beam patterns [1]. Since its introduction, this approach has been extended to a significant range of precursors leading to materials with semiconducting/metallic, magnetic, and superconducting properties [2]. Recent tool developments include the extension to new precursors and add-ons to run the software on electron microscopes from the main microscopy manufacturers [3]. I will present the latest open-access version of f3ast, including recent developments for faster, more accurate and transferable 3D nanoprinting.

For magnetic nanostructures, these fabrication capabilities are particularly powerful: f3ast converts digitally prescribed curvature, torsion, connectivity and structural chirality into physical parameters that reshape the magnetic energy landscape. It therefore provides a direct bridge from the design of a 3D geometry to the engineering of its magnetic behavior. Using this approach, we have investigated a range of 3D nanostructures, including magnetic nanowire circuits and double-helix architectures. I will describe some of these works, including the formation of topological magnetic stray fields via strongly-coupled domain wall pairs [4], the imprinting of fractional skyrmion tubes due to the breaking of geometric-magnetic chirality coupling [5], and the control over the spin texture around a Bloch-point singularity [6]. Together with aspects related to fabrication and magnetism, I will also show new methods we're developing for characterization of 3D magnetic nanostructures, including X-ray / electron microscopy tomography, and magneto-optics.

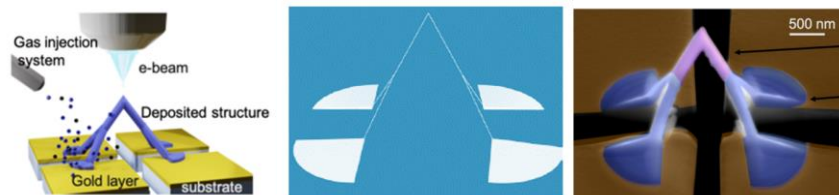


Figure 1. Example of nano-circuit fabricated by f3ast, here for the study of 3D superconducting properties [2].

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References

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