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Focussed Ions for Materials Design

Focused ion beam (FIB) technology has evolved from a versatile microfabrication and imaging tool into a powerful platform for atomic-scale materials design, enabling the modification, doping and restructuring materials with nanometer precision. Our research advances FIB capabilities to explore new pathways for unprecedented applications [1]. For instance, we recently demonstrated the local phase transformation of β- to ɣ-Ga_2O_3 through ion-induced lattice disorder, enabling site-specific tuning of electronic and optical properties for advanced device applications [2,3].

We also developed an ultralong, high-density data storage concept in radiation-resistant silicon carbide, based on optically active atomic-scale defects, allowing multi-layer, diffraction-unlimited optical data archiving beyond conventional media [4]. Certain ion species can induce defects that form color centers acting as single-photon emitters for quantum photonics; for example, Si^+ [5] and C^+ ions [6] have been used to create G- and W-centers in silicon that emit in the telecom O-band, ideal for fiber-optic communication to create long distance quantum networks.

Finally, we present our latest efforts toward deterministic single-ion implantation of group V donors in silicon for spin qubits, as well as isotopic purification of ^{28}Si via high-fluence implantation, paving the way for ultra-coherent quantum devices [7]. These results highlight the versatility of FIB technology as a precise tool for materials engineering at the nanoscale, bridging quantum technologies, advanced photonics, and high-density data storage.

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