Advancing Coherent In-Situ Cryogenic Electron Spin Resonance in Scanning Electron Microscopes

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Electron spin resonance (ESR) is a versatile analytical technique with broad applications in medicine, biology, and material sciences. While established techniques, including magnetic field gradients and advanced resonator designs, provide high spatial resolution, our custom-built sample stage for in-situ ESR at cryogenic temperatures within a modified Philips XL30 scanning electron microscope (SEM) offers new possibilities for insitu spin manipulation. Using a conventional ESR spectroscopy setup with Koelsch radical (α,γ-bisdiphenylene-β-phenylallyl) samples, we demonstrate fast signal acquisition of miniaturized sample sizes and enhanced sensitivity through cryogenic cooling. Our approach sets the foundation for future experiments using the non-radiative near field of a modulated electron beam to coherently manipulate the spin states, potentially enabling the generation of arbitrary potential shapes down to the nanoscale. This capability could open new avenues for coherent control of spin systems, offering a pathway to innovative applications in quantum technologies and material sciences.