

IRON-based superconducting electrodeposited films at Microwaves for the detection Of axiONs (IRONMOON)

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The IRONMOON project investigated the feasibility of superconducting FeSe coatings, to be produced by electrodeposition, for microwave haloscope cavities aimed at axion detection. The work integrated film growth, microwave surface-impedance measurements, and modelling of the expected performance under haloscope-relevant conditions.

On the materials side, an electrodeposition route for FeSe was successfully developed, including the identification of needed densification treatments and procedures designed to remove excess interstitial iron, which was found to be a limiting factor in the coating properties. This led to superconducting films with onset critical temperatures up to about 8 K, produced with thicknesses in the micrometre range. This activity generated a patent application for the electrodeposition process, confirming the technological relevance of the results.

In parallel, FeSe reference samples grown by pulsed laser deposition were investigated through microwave measurements enabling a comparative analysis of vortex dynamics and pinning properties. The vortex response in FeSe has been shown to be characterized by relatively weak pinning compared with other Fe-based superconductors (FeSeTe), but still compatible with haloscope operation in selected frequency ranges. A detailed analysis of the flux-flow resistivity indicates that the studied FeSe lies between the dirty and moderately clean regimes for vortex-core quasiparticles, resulting in a dissipation level higher than that observed in FeSeTe. These results indicate ample margins for material optimization, in both pinning and dissipation levels in the vortex cores.

In overall, the project demonstrated that electrodeposition of FeSe is a feasible route toward low-cost superconducting coatings, and identified the materials improvements still needed for actual microwave application in axion haloscopes.

Acknowledgements

The presented work was supported by MIUR-PRIN 2022 Project IronMOON Grant No. 2022BPJL2L.