Istituto SPIN
Genova, L'Aquila, Napoli, Roma, Salerno

SPIN Seminar series, mini-symposium on:

Innovations in Superconductivity at SPIN: Tailoring Materials for Big Science Challenges

In the coming decades, **Big Science** projects, such as particle accelerators, nuclear fusion reactors, and axion research, will demand superconducting materials that can operate under extreme magnetic fields, high temperatures, and radiation. These superconductors must exhibit high critical currents, isotropic pinning, and stability in demanding environments. While high-temperature superconductors (HTS) such as ReBCO are promising candidates due to their superior performance, they still face significant technical challenges and prohibitive costs. This makes the exploration of alternative materials crucial. CNR-SPIN's research on **iron-based superconductors** (**FeSeTe**, **Ba-122**) and **Thallium-1223 films** aims to develop cost-effective solutions tailored to meet the high demands of next-generation technologies.

In this mini symposium 4 short presentation will show our latest results:

Program 24/10/2024

14:30-14:35 Emilio Bellingeri **Introduction**

14:35-14:50 Valeria Braccini **Irradiation Effects on FeSeTe Thin Films Grown on Different Substrates**

14:50-15:05 Gaia Grimaldi **Anisotropy Pinning Effects in Superconductors beyond Jc**

15:05-15:20 Andrea Malagoli **Optimizing Ba-122 Superconductors: Pathway to High JC Multifilamentary Wire Production**

15:20-15:35 Alessandro Leveratto **HTS for Future Circular Collider beamscreen: Thallium-1223 coatings**

Abstracts

Irradiation Effects on FeSeTe Thin Films Grown on Different Substrates Valeria Braccini

Iron-based superconductors (IBS) are promising candidates for high magnetic field applications, such as in fusion plants and high-energy physics. Specifically, the Fe(Se,Te) family offers advantages over ReBCO in terms of Coated Conductor architecture and radiation resistance. We studied and optimized the deposition of Fe(Se,Te) thin films on CaF_2 and YSZ single crystal substrates, as well as on biaxially textured NiW tapes with a Zr-doped CeO_2 buffer layer, resulting in the first fully home-made Fe(Se,Te) Coated Conductors with a simplified architecture.

We focused on the effects of particle irradiation to understand and enhance pinning and the phase's robustness. Experiments with various particles and fluences revealed that Fe(Se,Te) is highly resistant to high-energy proton-induced damage. In contrast, the effects of heavy ions like Au and Pb vary with the substrate, potentially increasing critical current density and the irreversibility field at specific matching fields.

Anisotropy Pinning Effects in Superconductors beyond Jc Gaia Grimaldi

Big Science Projects drive the development of coated conductors that benefit from intrinsic isotropic materials like LTS (e.g., NbTi for the LHC at CERN and Nb_3Sn for ITER) or effective isotropic pinning materials like HTS for magnetic confinement in Fusion Energy.

This study examines the potential of Iron-Based materials, specifically Fe(Se,Te) thin films, by disentangling intrinsic anisotropy and pinning effects through angular transport measurements beyond Jc, complemented by detailed microstructure analysis. Our dual objectives are to achieve high vortex velocities at the operating limits of superconducting devices and to deepen our understanding of vortex and quasi-particle dynamics under extreme out-of-equilibrium conditions. Understanding material anisotropy can enhance vortex motion speed and control quenching currents beyond Jc, which are vital for selecting superconductors for specific applications (e.g., high-field magnets, Fault Current Limiters, Photon Detectors).

We compare Fe(Se,Te) with other superconductors, such as BSCCO (2D-like) and YBCO (3D-like), within the frameworks of the 3D anisotropic Ginzburg-Landau model and the 2D Tinkham's approach. This comparison reveals the dimensionality and anisotropies of Fe(Se,Te) in vortex dynamics and pinning. Additionally, TEM microstructure analysis of IBS-Fe(Se,Te) defects, which mimic the layered nature of HTS-YBCO, illustrates its characterization as a "Lego-block" material.

Optimizing Ba-122 Superconductors: Pathway to High JC Multifilamentary Wire Production Andrea Malagoli

The high interest on Iron-based superconductors, in particular the so called Ba-122 phase, is justified by their high transition temperature, huge upper critical field and nearly isotropic and field independent critical current, but it is still needed to explore and establish which can be their real applicative potential.

In an effort to explore the possibility for such superconductor to be industrially processed in practical superconducting wire useful for the building of the next generation accelerator magnets, CERN and CNR-SPIN joined in a collaboration agreement within the framework of the High Field Magnet Research and Development Program at CERN. The final goal is the fabrication of high J_C multifilamentary wires through a scalable PIT method optimized to reach high densification and texture in the powder core.

Here we present the work carried on at CNR-SPIN and the first results regarding both the powders and the first wires.

HTS for Future Circular Collider beamscreen: Thallium-1223 coatings Alessandro Leveratto

Thallium-1223 is being explored as a superconducting coating for the Future Circular Collider (FCC) beamscreen to improve beam stability at high energies (100 TeV). This study focuses on synthesizing nearly pure Tl-1223 films realized through solid state epitaxy at high-temperature and moderate high-pressure treatments to prevent thallium loss. The films, characterized for transport properties under FCC conditions, show promising bi-axial texture and good superconducting properties.