Microstructural Analysis of TI-1223 Superconducting Layers for the FCC Beam Screen





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Introduction

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A part of the FCC-hh design study explores different superconducting materials, which could be suitable to function as a coating on the beam screen, held at 50 K. Such a superconducting coating should be able to carry the beam image currents and lower the beam impedance in order to guarantee a high beam stability margin [1,2]. Our study focuses on the still technologically unexploited thalliumbased cuprates. For the development of the coating thin films of Tl-1223 are grown on untextured silver substrates. Here we present superconducting properties of the Tl-based films which are investigated by means of Scanning Hall Probe Microscopy. We compare the results from magnetic field mapping with microstructural features obtained with Scanning Electron Microscopy and Transmission Electron Microscopy where the chemical composition of the superconducting grains and especially the formation of the Tl-1223 phase is demonstrated.

Scanning Hall Probe Microscopy

• Mapping of remanent magnetic field: superconducting grains at different magnifications



HTS Coating for the Beam Screen



Scanning Electron Microscopy

• EDX elemental mapping: comparison between magnetic signal and elements in the sample



Meeting vacuum requirements, the synchrotron radiation will be absorbed by a **beam screen** kept at **50 K**.

There are consequences on the beam stability:

- ► Joule heating in the screen
- Excitation of wakefields

Both effects are described by **beam impedance** = proportional to **surface impedance** of material facing the beam.

- ► Current design in LHC: **copper**
- Surface impedance of copper at 50 K may not be low enough to guarantee a safe operational margin for the FCC-hh beam.
- Only HTS-materials have a lower surface impedance at 50 K.

HTS required properties:

- \blacktriangleright Critical current density $> 2.5 \times 10^8$ Am^{-2} at 50 K and 16 T
- Our proposition: Revisit the Tl-based compounds $Tl_xBa_2Ca_yCu_{y+1}O_z$, in particular **Tl-1223**

Transmission Electron Microscopy

• Superconducting phase forms a 600 nm thick layer



Samples

► Samples are reacted in electrochem-





- Films are deposited on untextured silver substrates
- ► Deposition time: 600 s
- Spot etched free with hydrochloric acid for magnetic field mapping



- TEM image shows clear evidence of stacking of different grains
- The superconducting phases of different grains can be determined through line scans
- ► TEM investigation shows sharp transition between Tl-1223 and Tl-1212 phase

Summary

- ► HTS beam screen: investigation of thallium-based superconductors
- Remanent magnetic field can be compared to copper content in the sample
- TEM investigations show single grains and their superconducting phases

References

[1] S. Calatroni, E. Bellingeri, C. Ferdeghini, M. Putti, R. Vaglio,
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[2] S. Calatroni and R. Vaglio. *IEEE Transactions on Applied Superconductivity*, 27(5), 2017.





