FCC-hh Nb_3Sn Wire Development: Exploring the Microstructure of Prototype Samples

Alice Moros[1], Mattia Ortino[2], Stefan Löffler[1], Maxim Alekseev[3], Anastasia Tsapleva[3], Pavel Lukyanov[3], Ildar M. Abdyukhanov[3], Victor Pantsyrny[3], Bernardo Bordini[4], Amalia Ballarino[4], Simon C. Hopkins[4], Michael Stöger-Pollach[1], Johannes Bernardi[1], Michael Eisterer[2]

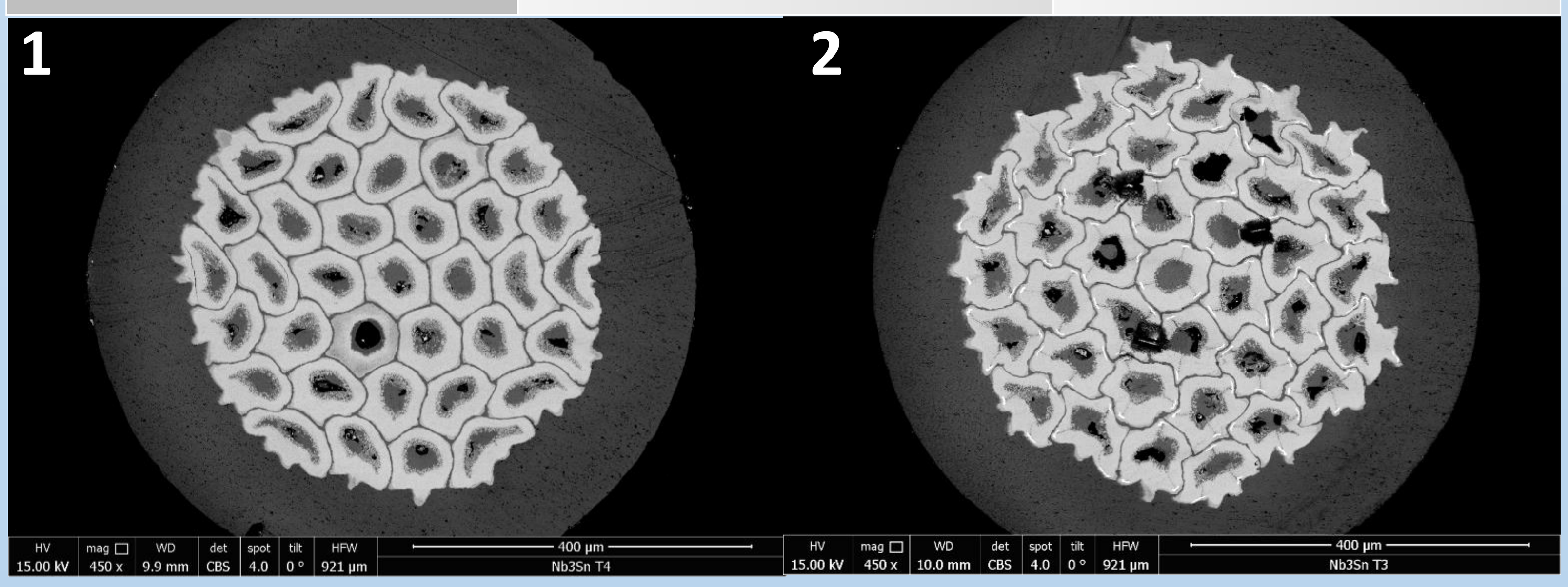
[1] TU Wien, USTEM, Vienna, Austria
[2] TU Wien, Atominstitut, Vienna, Austria
[3] A. A. Bochvar High-Technology Research Institute on Inorganic Materials, Moscow, Russia
[4] CERN, Geneva, Switzerland

Introduction

Nb_3Sn is currently the best candidate material for the realization of the 16 T FCC superconducting dipole magnets. Its microstructural characterization is a key point for understanding how different designs and heat treatments in the manufacturing process influence the homogeneity of elemental concentrations all over the wire cross section, also revealing which layout could be the one leading to optimal superconducting performance.
In this work, two prototype internal tin Nb_3Sn wires produced by the same heat treatment and presenting different sub-element structures are compared.

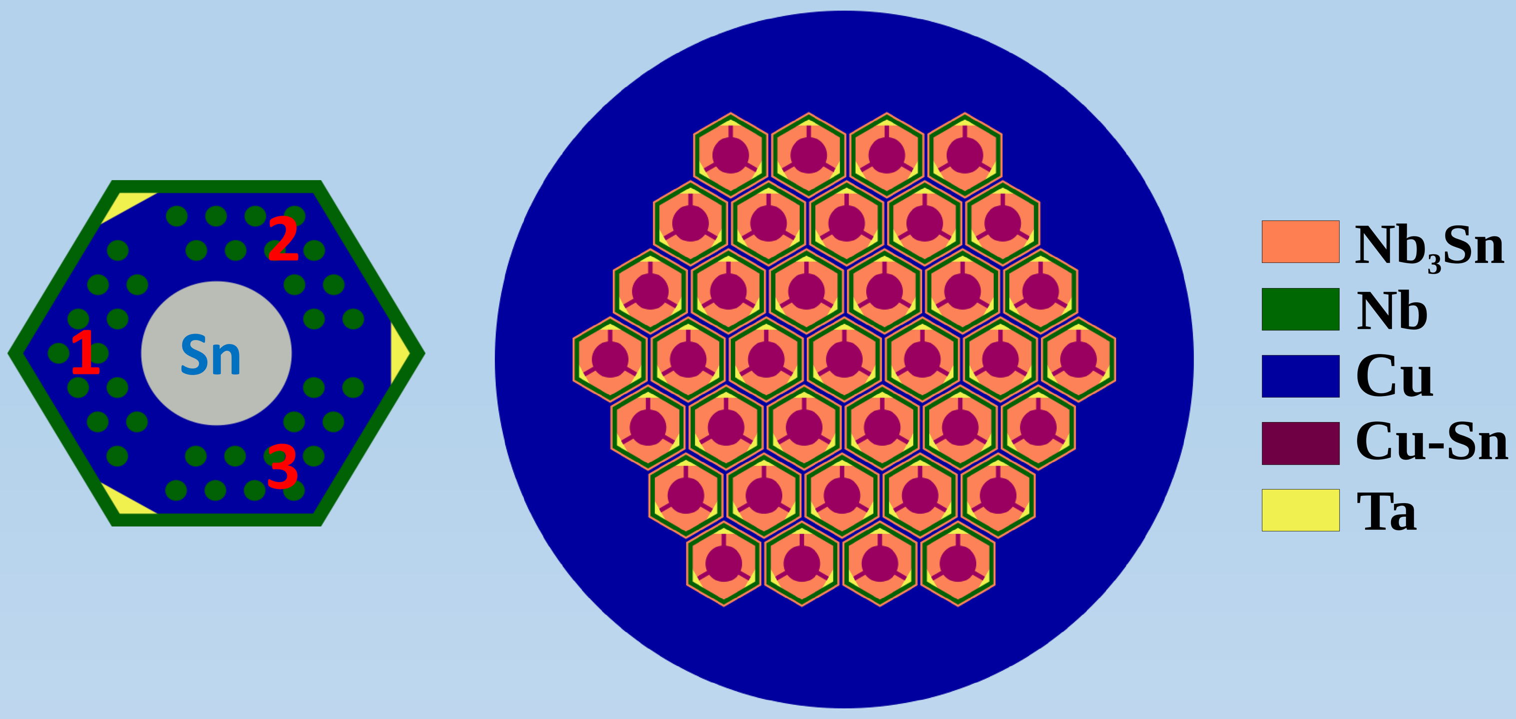
Samples

Wire identification	"Standard" Layout (1)	"Clusters" Layout (2)
Wire dia, mm	0.7	0.7
Barrier	Distributed Nb	Distributed Nb + Ta
Subelements	37	37
Subel. size, µm	80	80
Heat treatment	210 °C, 50 h + 400 °C, 50 h + 665 °C, 50 h	210 °C, 50 h + 400 °C, 50 h + 665 °C, 50 h



What does "sub-elements with clusters" mean?

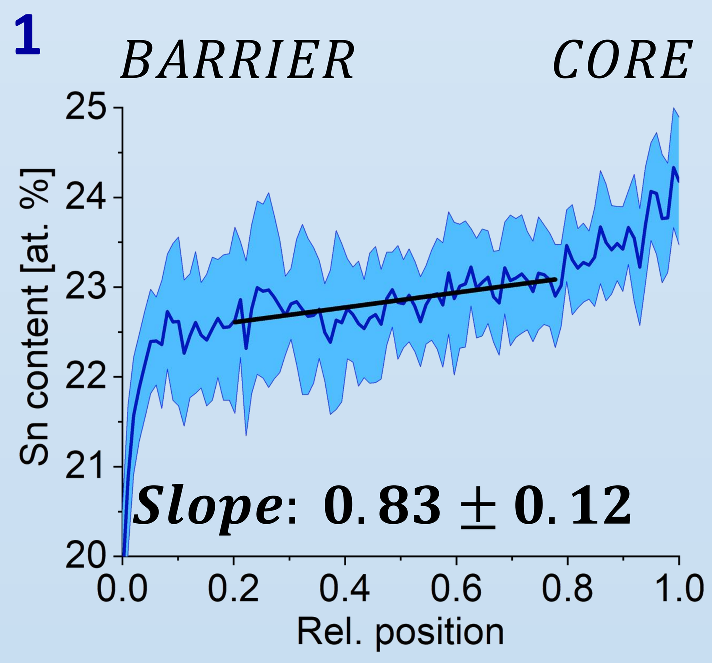
Sub-element starting configuration | **Wire configuration after heat treatment**

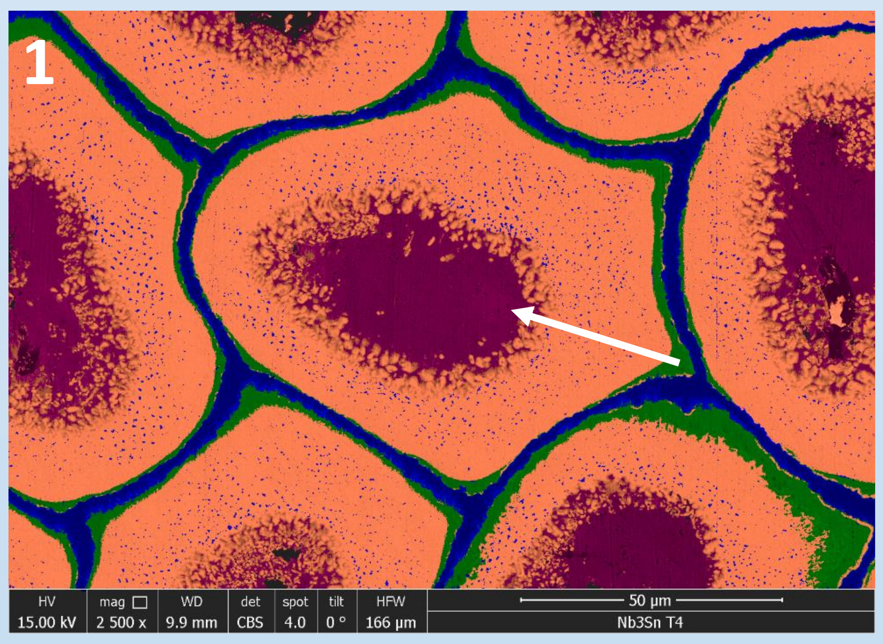


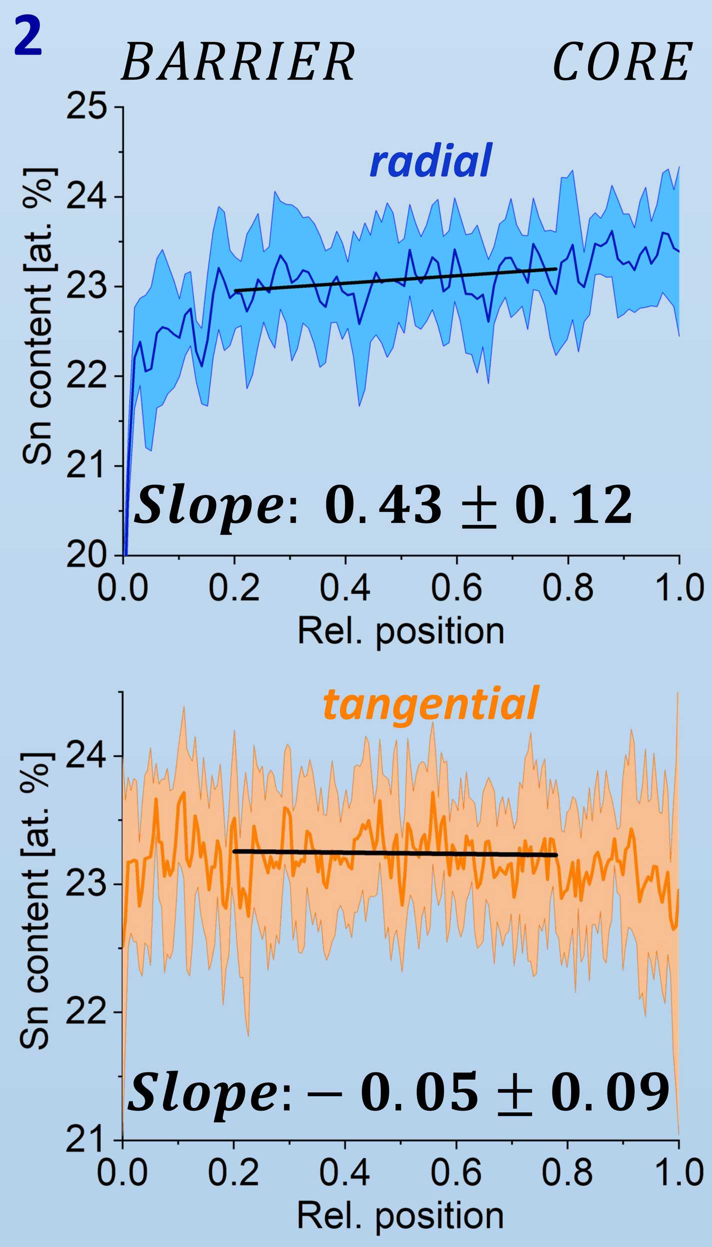
Results

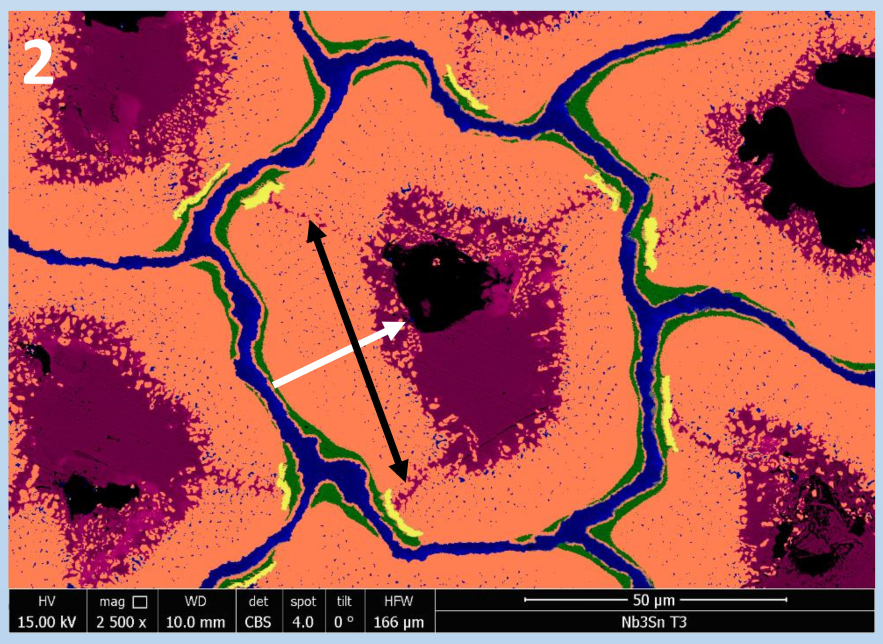
Homogeneity Analysis

The homogeneity of elemental concentrations was investigated with a main focus on the Sn concentration: energy dispersive X-ray (EDX) spectroscopy was employed with scanning electron microscopy (SEM), performing EDX line scans along the radial direction (from the Nb barrier to the Cu-Sn core) in wires with "standard" sub-elements and along both radial and tangential (cluster width) directions in wires with "clusters" sub-elements. In particular, a statistical analysis was carried out by acquiring and evaluating the EDX data of ten sub-elements for each wire.









Radial direction (⟶)
Tangential direction (⟷)

Conclusion and Outlook

This work shows that the Sn concentration is more homogeneous in the "clusters" sample: in fact, the Sn gradient is reduced by a factor of 2 with respect to the "standard" sample. The sub-element with clusters seems therefore to have a great potential in terms of producing wires with higher homogeneity and better performance. These results demonstrate that other possible cluster configurations can lead to further improvements in order to reach the FCC target.

Acknowledgements

This work is part of the Marie Skłodowska-Curie Action EASITrain, funded by the European Union's H2020 Framework Programme under grant agreement no. 764879.