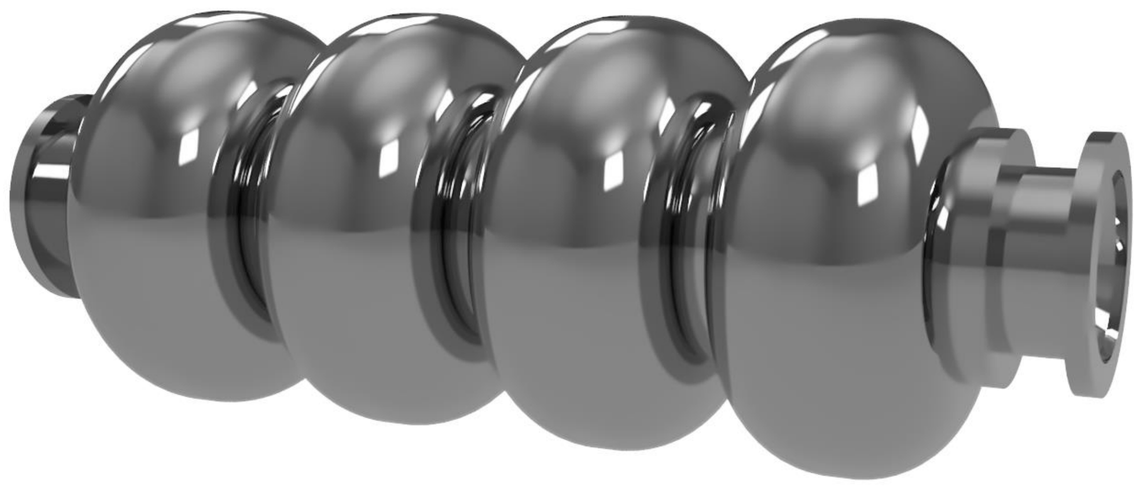
Crystallographic Characterization of Nb3Sn Coatings and N-Doped Niobium via EBSD and SIMS

THP017

J. Angle[1], J. Tuggle[1], U. Pudasaini[2], G. V. Eremeev[3], C. E. Reece[3], M. J. Kelley[1, 2, 3]
[1]Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA
[2] Applied Science Department, The College of William and Mary, Williamsburg, VA 23185, USA
[3] Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA

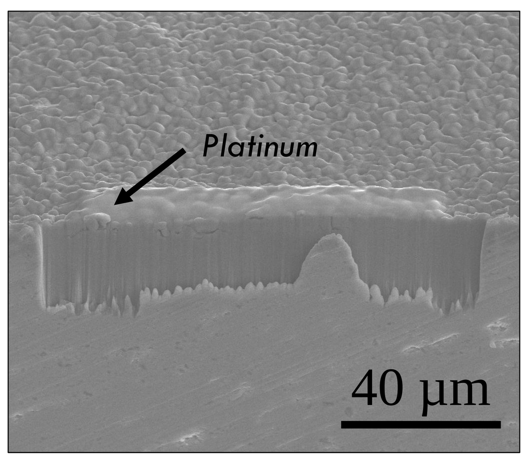


Abstract

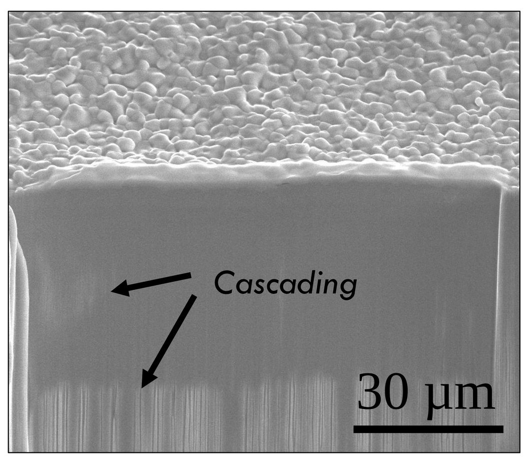
- Nb_3Sn coatings and N-doped niobium are materials which improve the operational cost and efficiency of SRF cavities, yet certain characteristics and mechanisms are not well understood.
- Currently crystallographic characterization, specifically EBSD, of these materials are highly motivated as It provides discernment into nucleation and growth of NB_3Sn coatings as well as the surface characteristics of N-doped Niobium.
- Insight into the acquisition of quality EBSD data by means of sample preparation is additionally discussed.

Characterization of Nb_3Sn

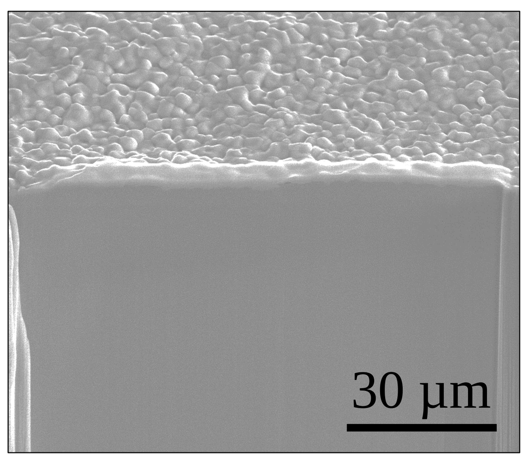
FIB Polishing has been shown to be an effective method to prepare EBSD quality cross-sections for NB_3Sn coating. However, a detailed method to date has not been explained. Below is a series of images which Show the FIB polish process.



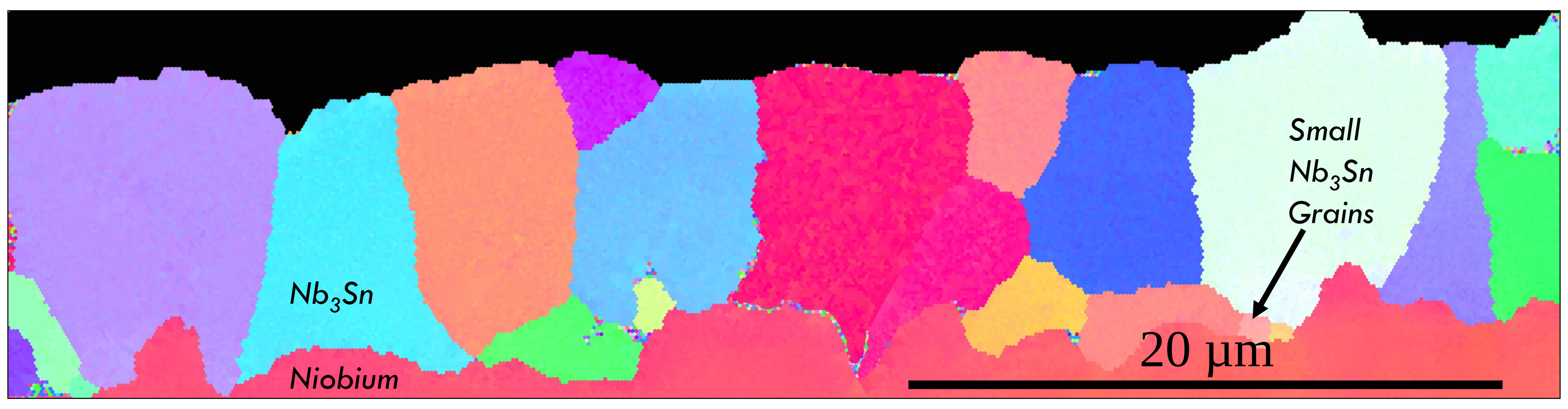
30 kV/21 nA FIB beam used to mill away a portion of the cross-sectioned surface



Cross-section following the initial removal of material. Cascading is evident

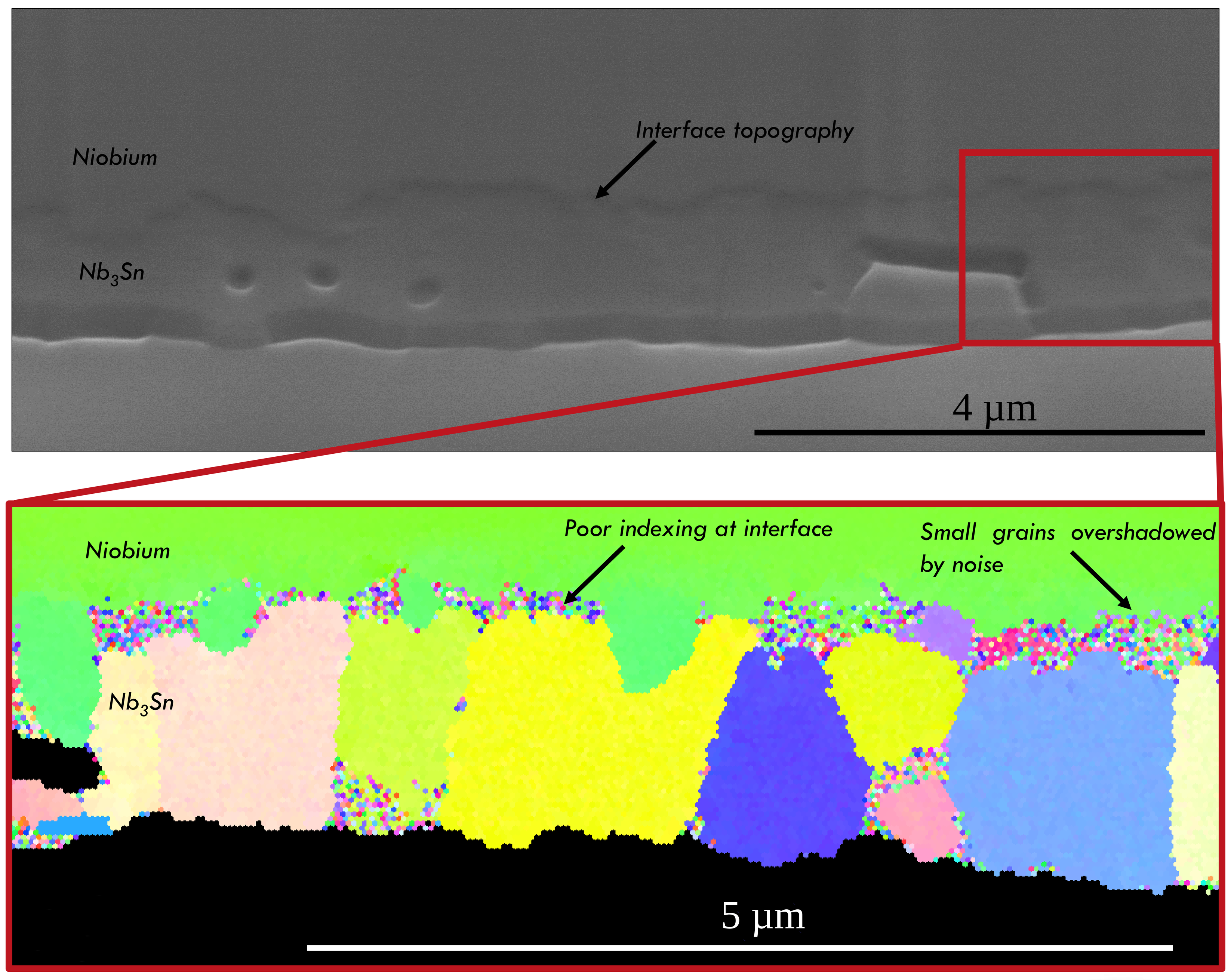


Final Surface provided by polishing steps using 5 kV/1.3 nA followed by 2 kV/0.71 nA



Quality EBSD Map acquired on Nb_3Sn coated Niobium Substrate. Small Nb_3Sn grains are evident at the Nb_3Sn/Nb interface

During the FIB polishing step (5kV/1.3 nA, 90° Incidental beam), over-polishing should be avoided which causes topographical differences at the Nb_3Sn/Nb interface.

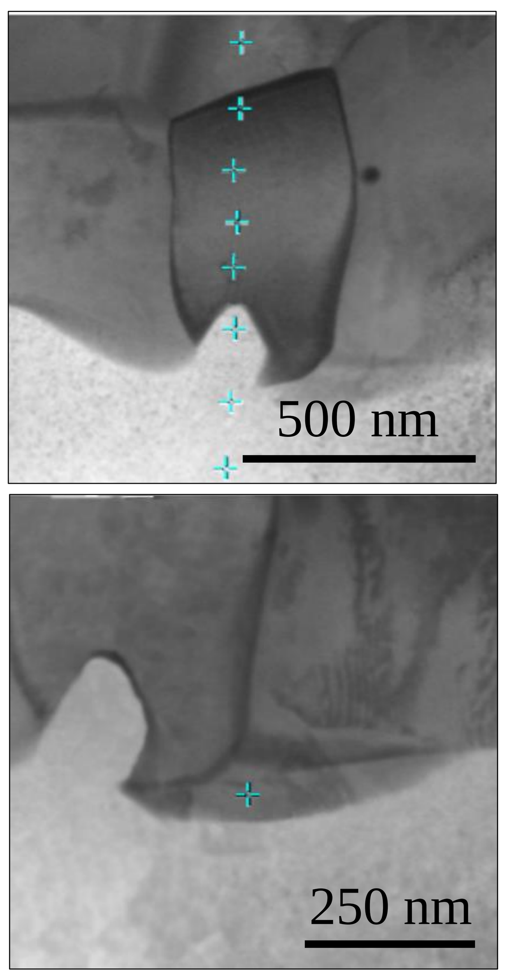


Top. *Shows a micrograph of a FIB polished sample which had been over-polished.* ***Bottom.*** *The resultant EBSD orientation Map*

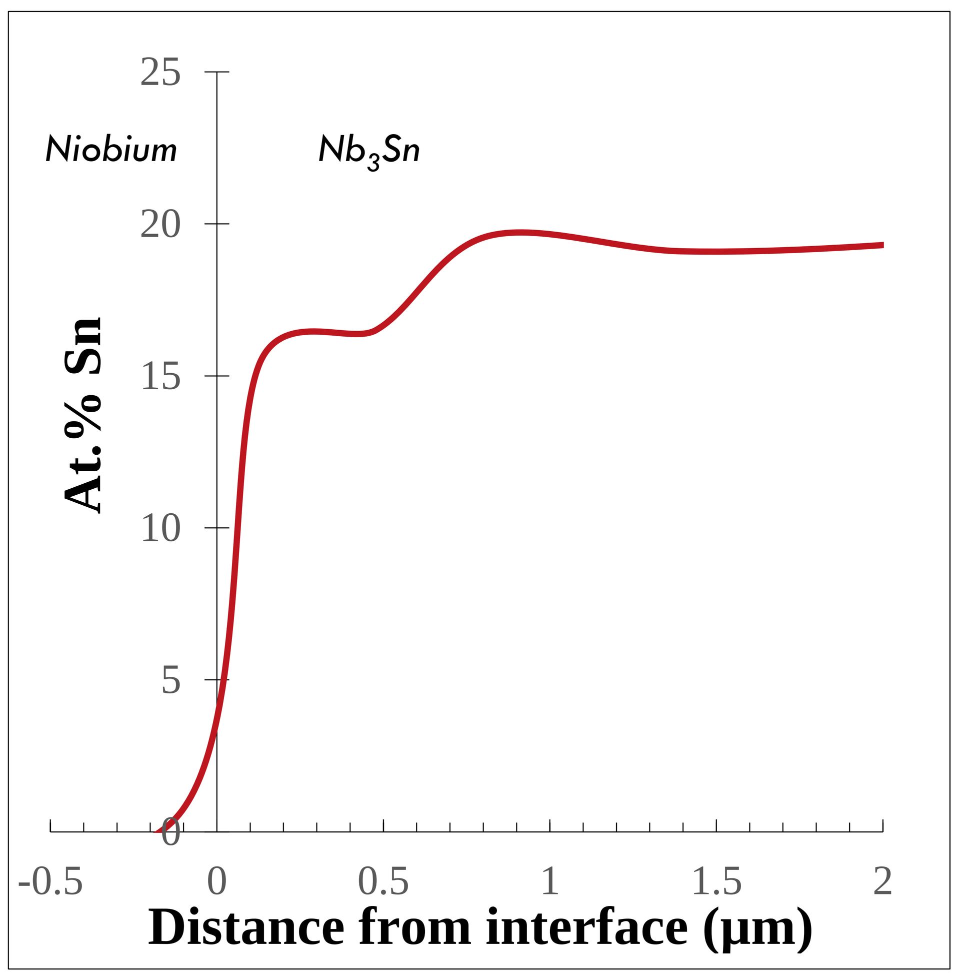
Acknowledgements

- Natilie Sievers and Chris Winkler for assistance with SIMS and TEM work.
- Priya Venkatraman
- Nanocharacterization and fabrication laboratory @ Virginia Tech
- Work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under contract DE-AC05_06OR23177. Grant No. DE-SC0018918.

TEM-EDS was performed to elucidate a diffusion profile for Sn. Also, even smaller grains at the interface were observed.



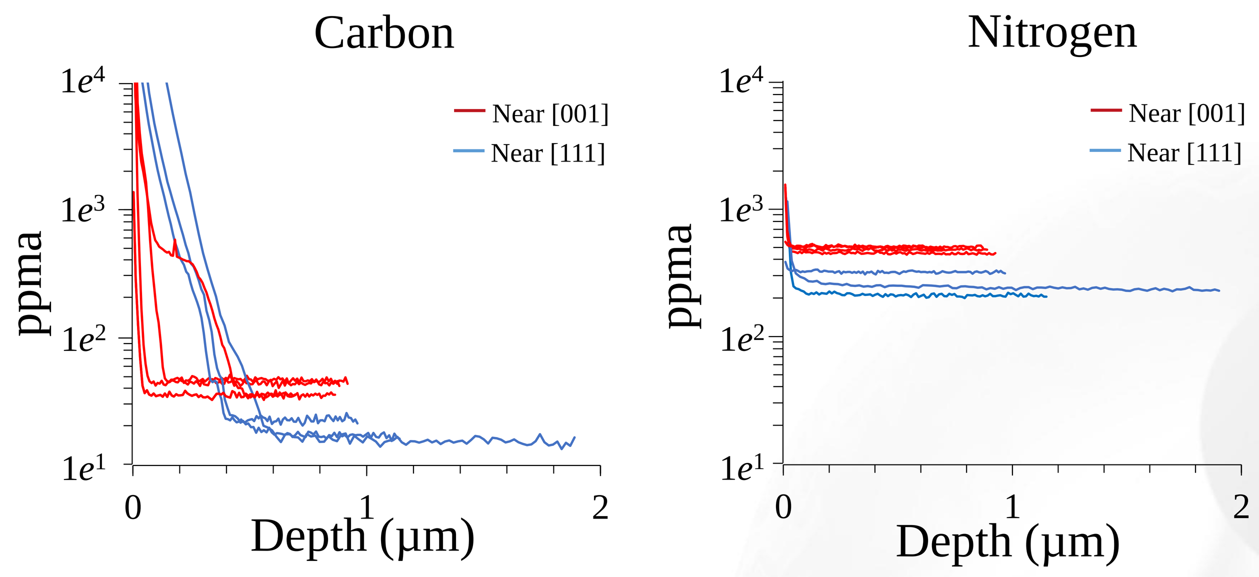
Top. *TEM image of Nb_3Sn Grains showing EDS locations* ***Bottom.*** *Increased magnification Nb_3Sn interface. Small grains at interface are observed. Sn concentration found to be 10.6% at this location. As opposed to the 20% found in the bulk Nb_3Sn*



Plot showing the change in tin concertation as a function of proximity to the Nb_3Sn/Nb interface

Characterization of N-Doped Niobium

EBSD performed on N-doped Niobium coupons showed a preferred surface orientation to either the [001] or [111] planes. SIMS performed on targeted [001] and [111] grains showed C,N,O concentration differences between the two grains orientations.



Top. *EBSD map of a Sample with a [001] preferred surface orientation. Locations where SIMS analysis are performed are noted* ***Bottom.*** *Resultant SIMS depth profiles. Oxygen data not shown.*

Summary

- Updated FIB methods used to remove cascading an to prevent from over polishing which causes poor indexing via EBSD
- Small grains at the surface revealed by EBSD. TEM-EDS showed tin depletion at interface, suggesting nucleation sites
- EBSD of the N-Doped samples showed preferred surface orientation of either [001[or [111] grains
- SIMS performed on targeted grains found differences in C,O and N concentrations between [001] and [111] grain.