Niobium Grain Strain Investigation Using Electron Backscattered Diffraction (EBSD)

R. E. Goddard (National High Magnetic Field Laboratory), L. Narramore (Lake Alfred Middle School, Lake Alfred, FL), and J. Norris (Lake City Middle School, Lake City, FL)

Introduction

Strain within a single grain can be inferred directly by slight changes in the crystal orientation continuously measured by EBSD. Many grains of engineered materials are exposed to stresses in a variety of directions inducing strain with a full three-dimensional expression. Dislocations and rotations in the same direction are ideal for simple quantification of the residual strain as in the case with a rolled sheet of niobium and copper. Highly strained niobium when cooled to normal superconducting temperature below approximately 9 degrees Kelvin has a greatly reduced current-carrying capacity. Even a small amount of strain can have a dramatic effect. While strain can be measured by EBSD determining the distortion of the atomic lattice [1] it is dependent on a high resolution electron backscattered pattern (EBSP). The orientation change may be accurate enough to measure the strain between intragranular points separated by a minimum of 20 nanometers [2]. This study investigates the feasibility of measuring the strain in an individual grain of below 1 percent.

Experimental

An individual grain of niobium was selected after a rolled sheet was prepared by standard metallographic procedures and examined by an EDAX Orientation Imaging Microscopy (OIM) analysis system on a Zeiss 1540 XB Field Emission Gun Scanning Electron Microscope (FEGSEM).

Results and Discussion

The misorientation from point to point within the selected niobium grain (**Figure 1**) is given in **Figure 2**. Applying the standard formula: **ε** (strain) =**d** (lattice spacing)/**R** (radius of rotation circle), the average residual grain strain from point to point is approximately 0.003 percent. Using this method and averaging all grains it is proposed to correlate this with the actual current carrying ability of the niobium to be an accurate predictor of the suitability of the manufactured conductor.

Figure 1. Orientation Map of Niobium Grain

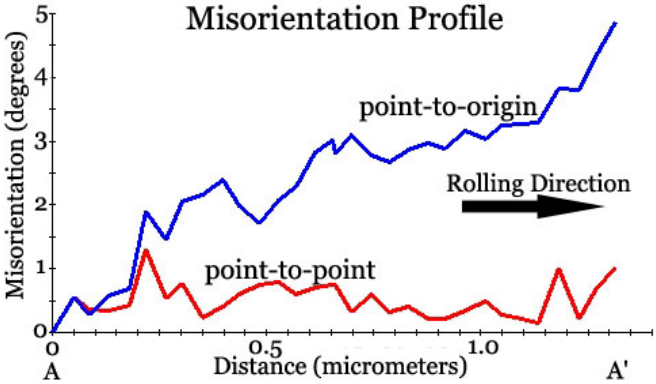

Figure 2. Plot of Intragrain Misorientation

Conclusions

Using this method it is possible to determine the strain at which superconductivity is affected once calibrated to the corresponding experimental data.

Acknowledgements

This work has been supported by the National Science Foundation (NSF) award number DMR-9527035 with appreciation for additional funding by NSF's Research Experience for Teachers (RET) program.

References

[1] R. E. Goddard *et al.,* Microsc. Microanal. 13 S2 (2007) 940.
[2] R. E. Goddard *et al.*, Microsc. Microanal. 16 S2 (2010) 710.