Auger Electron Spectroscopy and Ar Sputtering for the Determination of Y_2O_3 Buffer Layer Thickness in REBCO Superconducting Tapes

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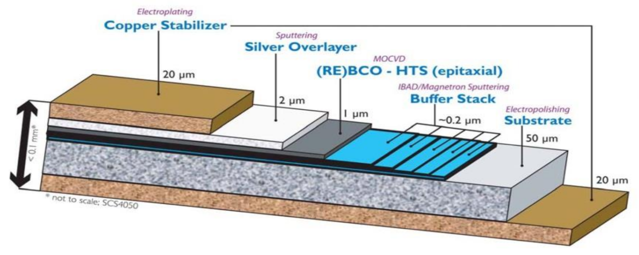
Motivating questions

To better understand the delamination behavior observed during peel testing in REBCO tapes, we are using scanning laser confocal microscopy and Auger Electron Spectroscopy (AES) to answer the following questions:

- In what tape layer is separation occurring, and what is the associated layer morphology?
- What microstructural features are associated with the peel test results?
- What factors contribute to sample-to-sample variability in the measured peel test strengths?



Acknowledgements

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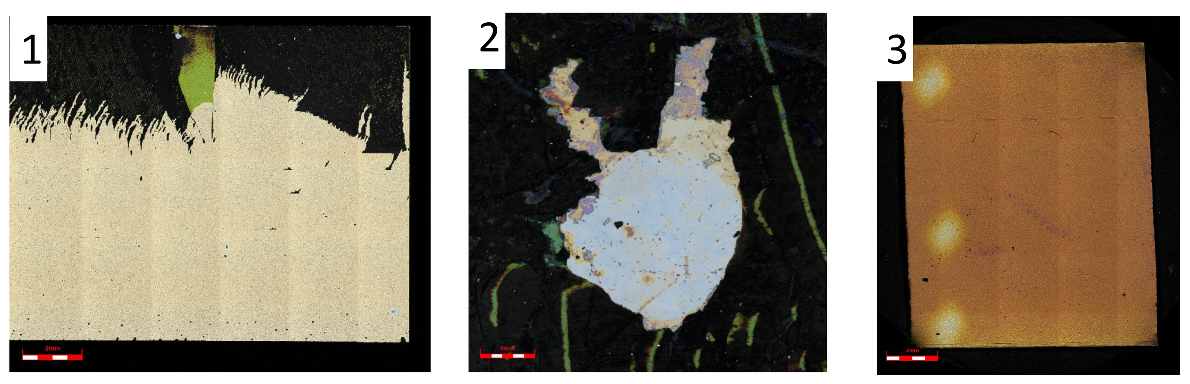
Samples under investigation

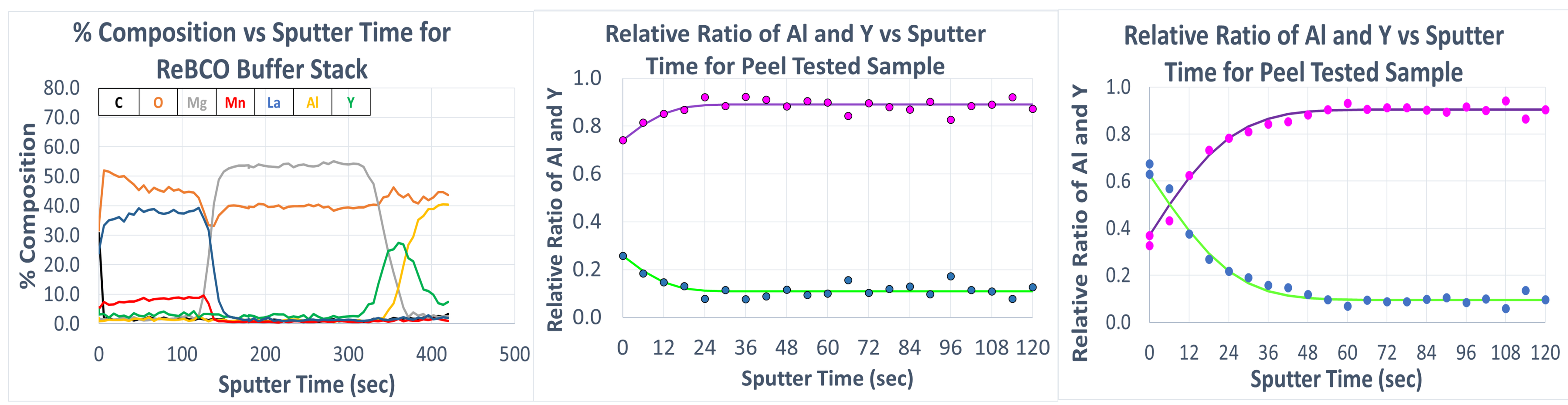


Samples 1 and 2 were peel tested by SuperPower and then characterized after testing by UW-Eau Claire. Some sample details:

1. Sample delaminated partially in the buffer region (lighter-colored region) and REBCO region (darker-colored region)
2. A defect in the REBCO that exposes underlying buffer layers, identifiable by color
3. One of three Y_2O_3 standard samples used to create a calibration curve that has been sputtered 3 times (sputter locations are the white ovals on left edge)

Auger sputtering technique development

Step 1: Perform Ar sputtering to get % composition data. Normalizing the Al and Y percentages give us curves that can be fit.



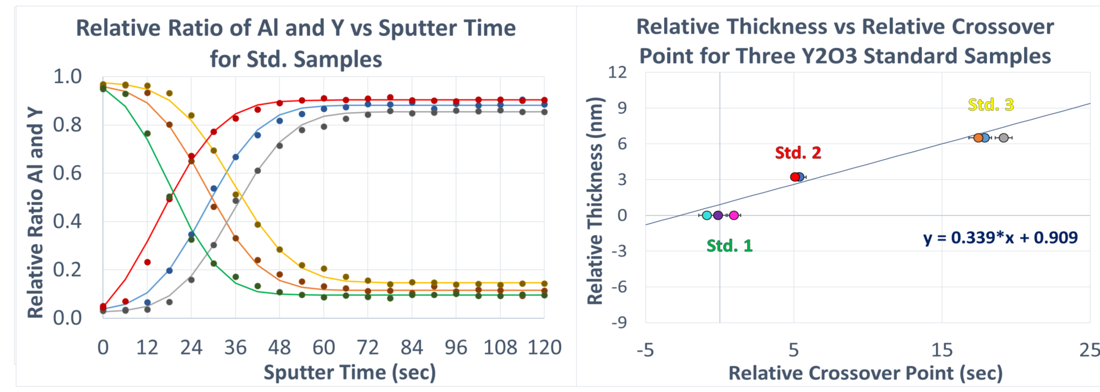
Composition data with sputtering depth (x) fit with the Gaussian Error (ERF) function.

$$F(x) = \frac{A}{2}\left[1 + ERF\left(\frac{x-\mu}{\sigma\sqrt{2}}\right)\right] + B$$

The point where Y and Al percentages cross is designated the "crossover point". Since we have the equation of the fit, we can calculate a crossover point for each sample regardless of curve shape.

Main Point: % composition data allows us to create normalized Al and Y curves. We fit those curves with ERF, and determine a crossover point using the fit's equation.

Step 2: Create a calibration curve by sputtering standard samples with known Y_2O_3 thickness



Calibration curve for determining Y_2O_3 layer thickness

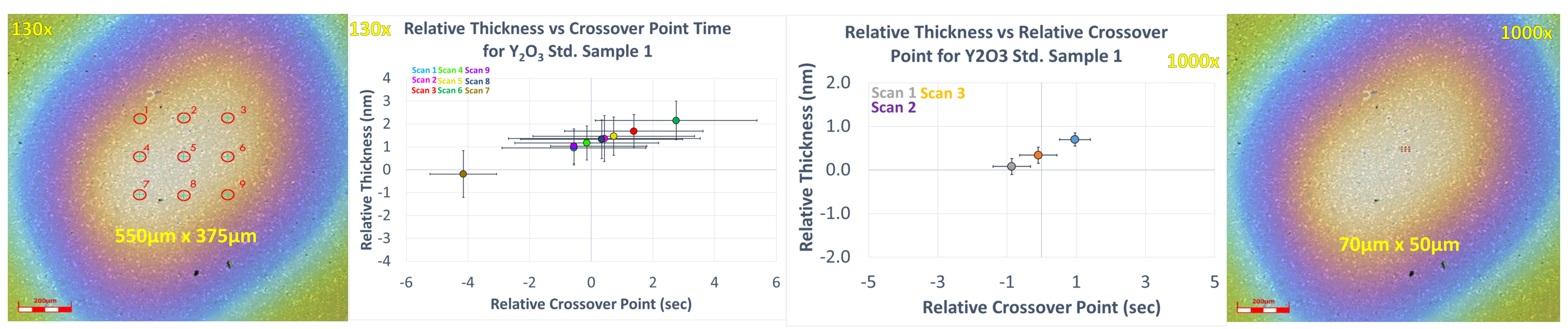
Three standard samples with known Y_2O_3 layer thicknesses were sputtered to determine their crossover points. We then created a calibration curve by plotting the known thicknesses against their crossover points.

The thickness of a Y_2O_3 layer can be determined by plotting it's crossover point on the calibration curve.

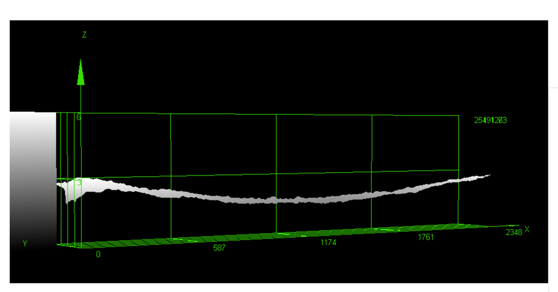
Main Point: Three standard Y_2O_3 samples were sputtered. Their crossover points were plotted against their known thicknesses. This calibration curve can be used to determine thicknesses of other Y_2O_3 layers by plotting their crossover points on the curve.

Assessment of technique variability

Step 3: Determine the accuracy of this technique and reduce measurement variability



Auger data was initially collected at 130x (using the SEM feature of the Auger as a guide). Confocal microscopy, right, revealed that the sputter area was a bowl shape, and the variation in our crossover points was caused by data being collected from the edges of the bowl.



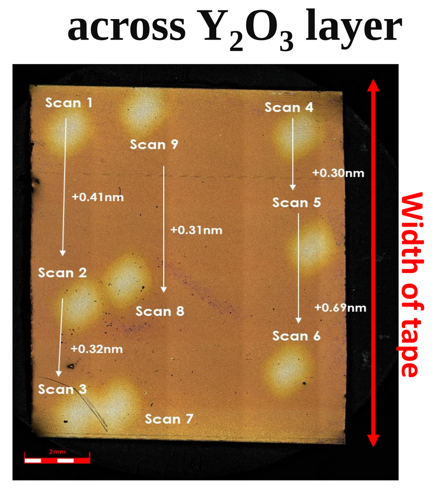
By collecting data instead at 1000x, we tightened the data collection area. Our variability in our crossover times dropped by a factor of 4, which subsequently reduced our thickness measurement error to the order of tenths of nm.

Main Point: By decreasing our data collection range, we decreased our data variation by a factor of 4, increasing the accuracy of our thickness measurements.

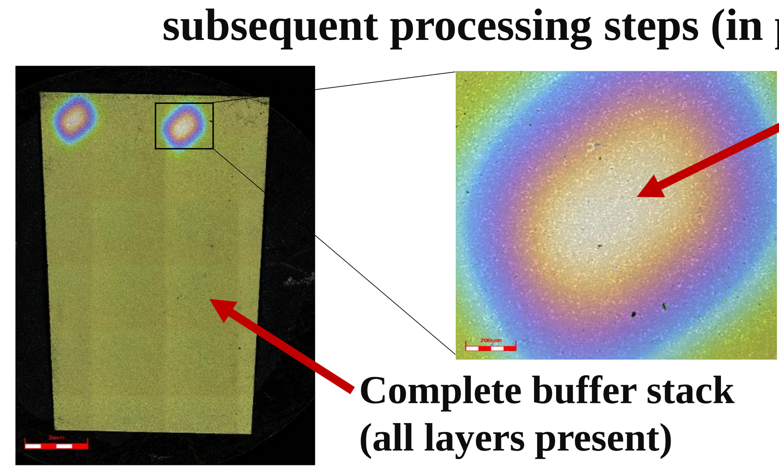
Applications and assessment

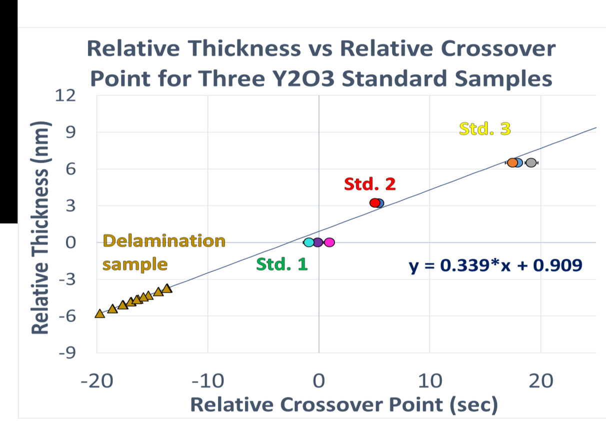
Step 4: Extend technique to other variables of interest

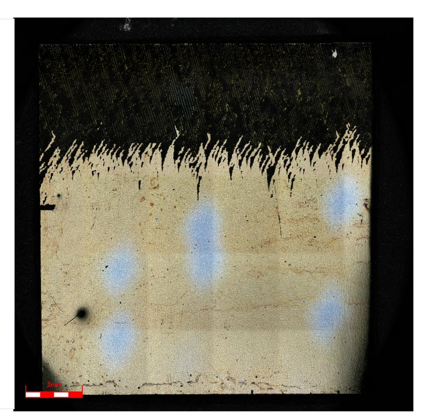
(1) Thickness variation across Y_2O_3 layer



(2) Assess changes in buffer layer thickness after subsequent processing steps (in progress)







(3) Determine thickness of Y_2O_3 layer for buffer side of REBCO peel-tested tape

Main point: This approach can be applied to a variety of situations. In particular it allows us to determine the remaining thickness of delaminated layers, such as the exposed Y_2O_3 buffer layer shown here.

Summary:

In this work we developed a technique to determine the thickness of the Y_2O_3 buffer layer in REBCO superconducting tapes using Ar sputtering.

Normalized Al and Y composition data was curve fit with the ERF function, and the crossover point, where the two fit curves intersect, was determined.

We created a calibration curve by plotting the crossover point for three Y_2O_3 samples against their know thicknesses.

By decreasing our scan area, we decreased our thickness measurement variability to tenths of nanometers.

We applied the technique to peel-tested REBCO tapes, and we determined the thickness of exposed Y_2O_3 buffer layer.