# Measuring thickness in thin NbN films for superconducting devices

O. Medeiros, M. Colangelo, I. Charaev, K. K. Berggren
*Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139*
omedeiro@mit.edu

We present the use of a commercially available fixed-angle multi-wavelength ellipsometer for quickly measuring the thickness of NbN thin films for the fabrication and performance improvement of superconducting nanowire single photon detectors. The operation of many superconducting devices is intrinsically dependent on the film's kinetic inductance which can be related to the film's thickness. Many methods for measuring the thickness are either time consuming, destructive, or rely on some assumption of the material's properties which often results in the use of inaccurate approximations. As a result, these approximations subtract from the fabrication quality and ultimate performance of such devices.

In this paper we determined the thickness and optical constants of NbN thin films using ellipsometry. Traditional ellipsometer parameters, $\Psi$ and $\Delta$, relating to the change in magnitude and phase of the reflected polarized beam, were measured. They were then used to fit generated $\Psi$, $\Delta$ curves for each wavelength as a function of the film's thickness and optical constants. The generated data was produced using OpenFilters, an open-source software package for simulating thin film optical models and was fit to the measured data using the Marquardt-Levenberg algorithm. The thicknesses determined by the fitting were compared to x-ray reflectivity and sheet resistance measurements and the optical properties were used to track changes in the film over time.

The results show that a commercially available fixed-angle ellipsometer can provide accurate characterization of absorbing thin films. Based on these results, the tool expands our understanding of the material and would greatly benefit applications that rely on kinetic inductance or other thickness-dependent electrical properties. This characterization can lead to new investigations on the effect that deposition parameters have on thin films.

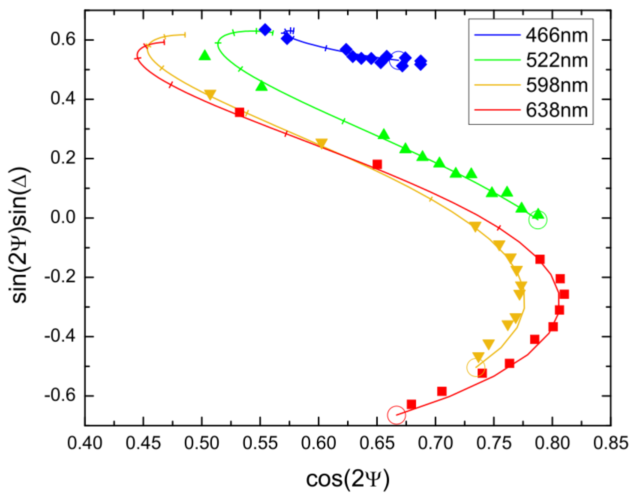


Figure 1. The inferred Ψ, Δ values for each sample are plotted as closed shapes. The legend denotes the corresponding wavelength and its respective color. The curves show simulated data using the optical constants determined by multi-sample analysis. The curves increase from zero thickness (open circles) to 60 nm in 10 nm increments (tick marks).

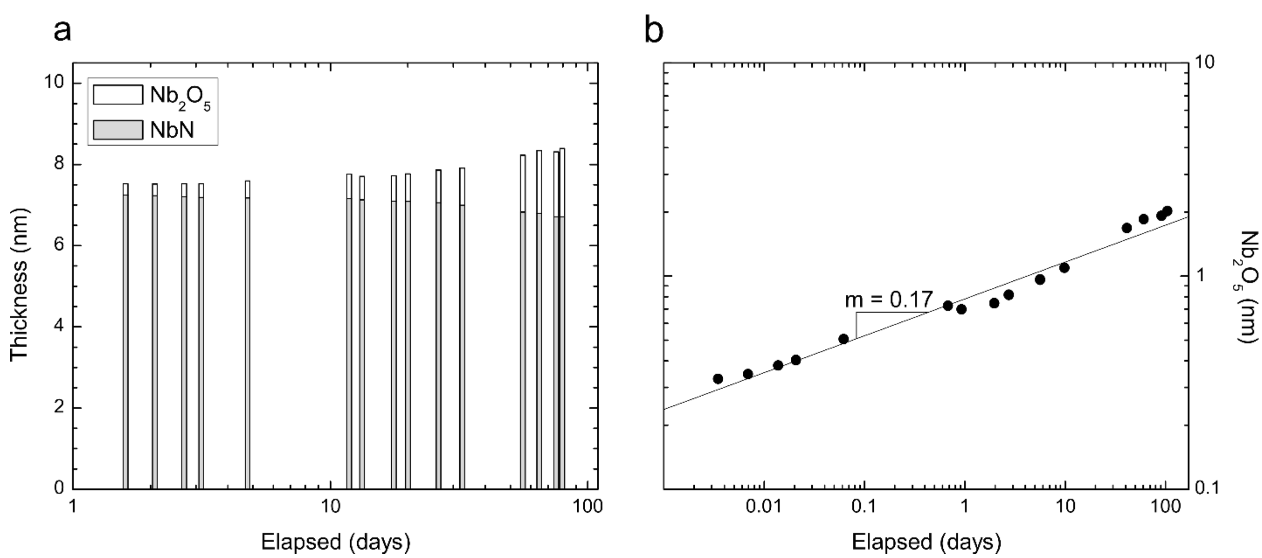


Figure 2. a) Stacked thickness of $Nb_2O_5$ on NbN over a duration of 100 days. The ellipsometer measurements show a decrease in NbN thickness and an increase in $Nb_2O_5$ thickness. The $Nb_2O_5$ is shown in white on top of the NbN shown in gray. b) The same $Nb_2O_5$ thickness measured by the ellipsometer at different intervals after being removed from the deposition chamber is shown with a linear fit.