NbN Thin Films: Growth and Characterization

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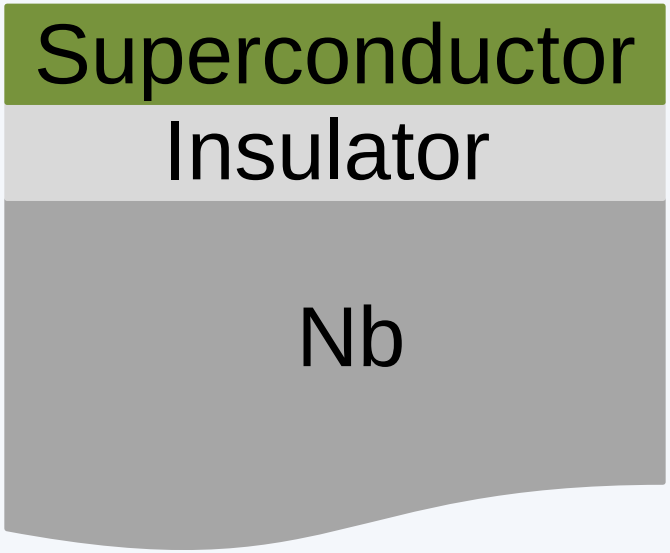
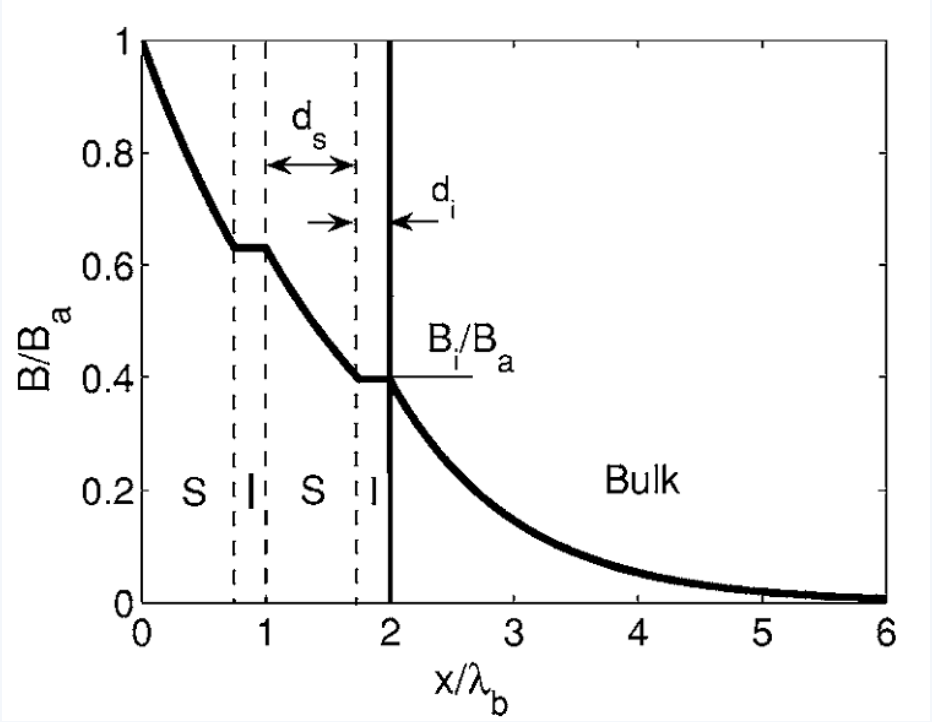
Outline

- Motivation
- NbN/MgO(100) Thin Films
  - Surface Morphology (AFM)
  - Structure (XRD, RRR)
  - Superconducting Properties (SQUID)
- Multilayer Films
- Conclusions and Future Work

Can new materials push performance limits?

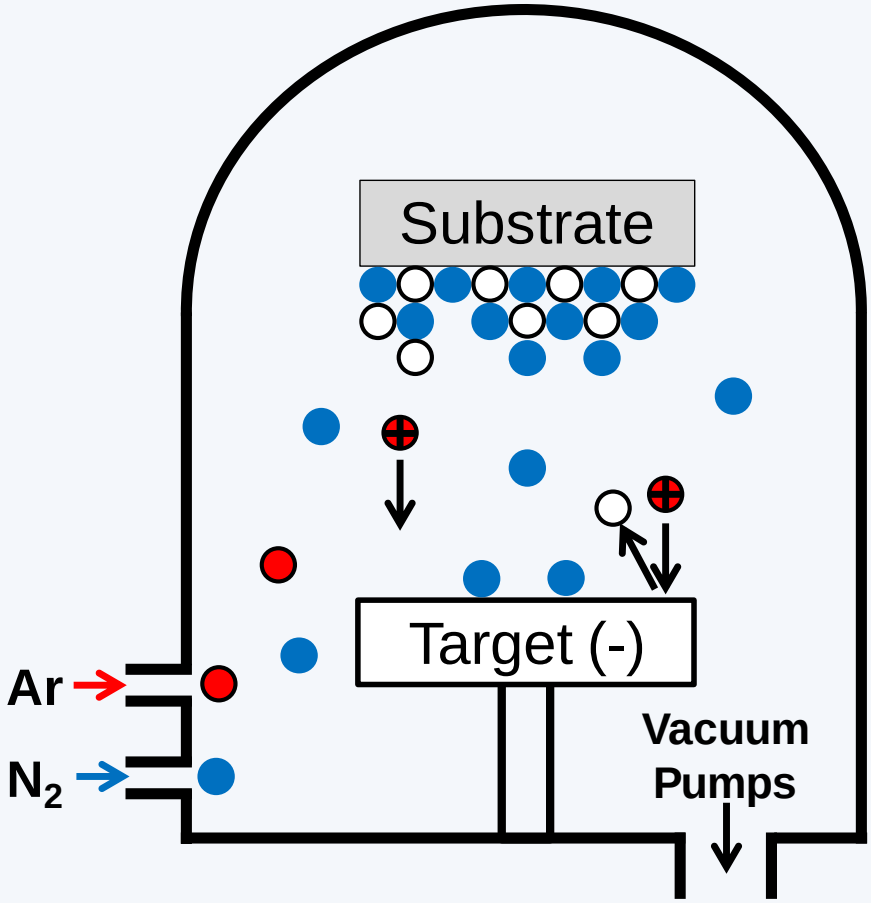




A. Gurevich, *Appl. Phys. Lett.* **88**, 012511 (2006).

Higher critical field → Higher accelerating gradient of interest in defense as well as scientific applications.

DC Reactive Sputter Deposition



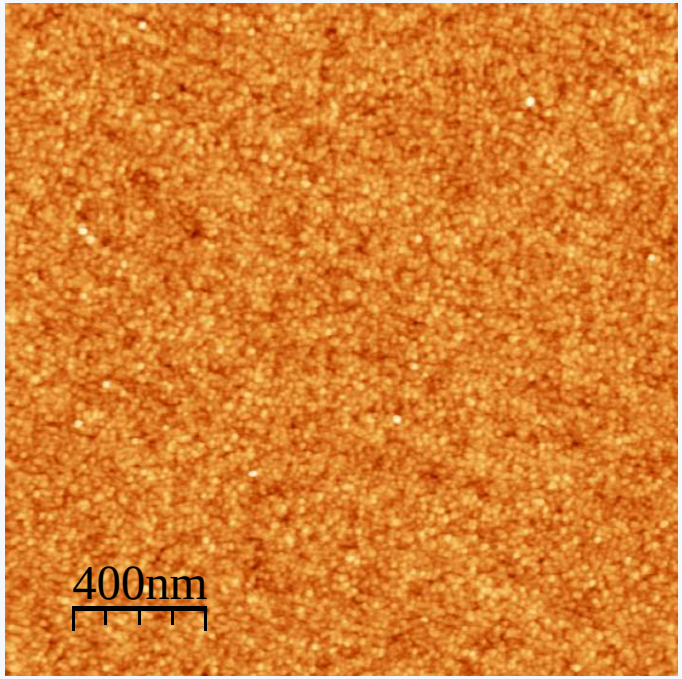
$Ar:N_2$ ratio affects film structure and properties

Fixed total pressure at 3.4 mTorr

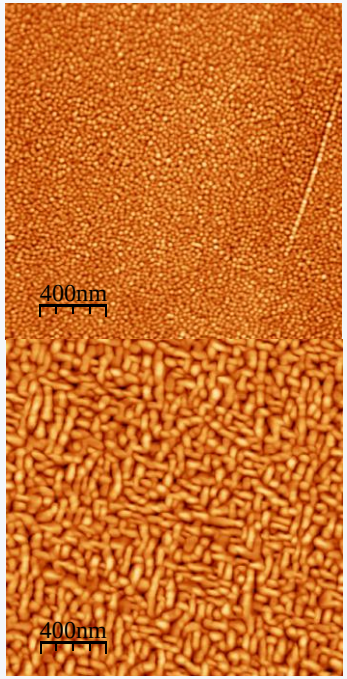
Varied partial pressures

Surface Morphology

NbN



Nb(100)



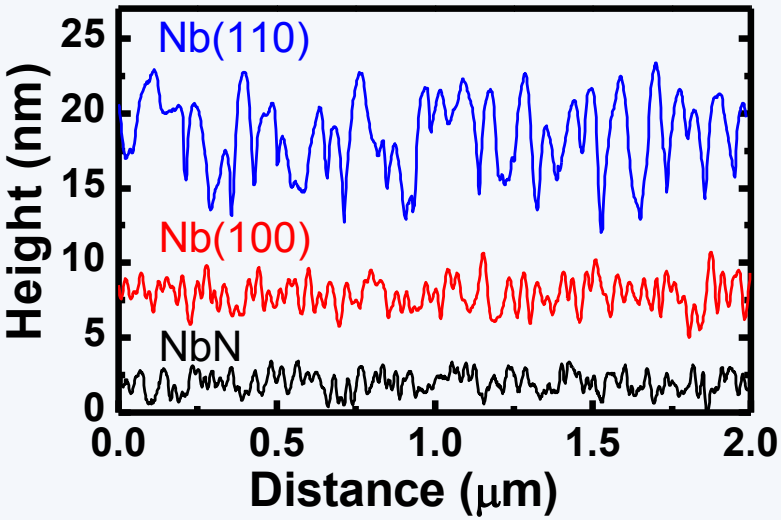
Nb(110)

RMS Roughness for comparable film thickness:

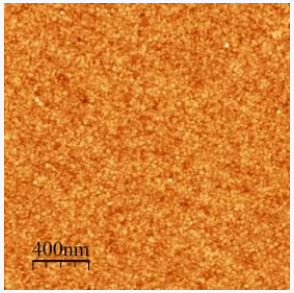
200 nm NbN <1 nm

100 nm Nb(100) 1.21 nm

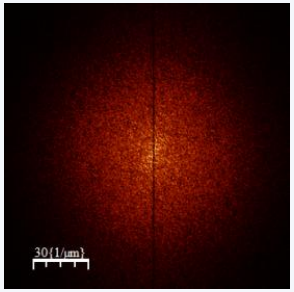
100 nm Nb(110) 2.45 nm



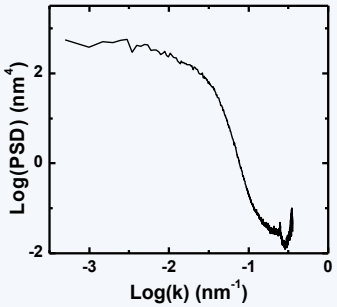
Surface Morphology

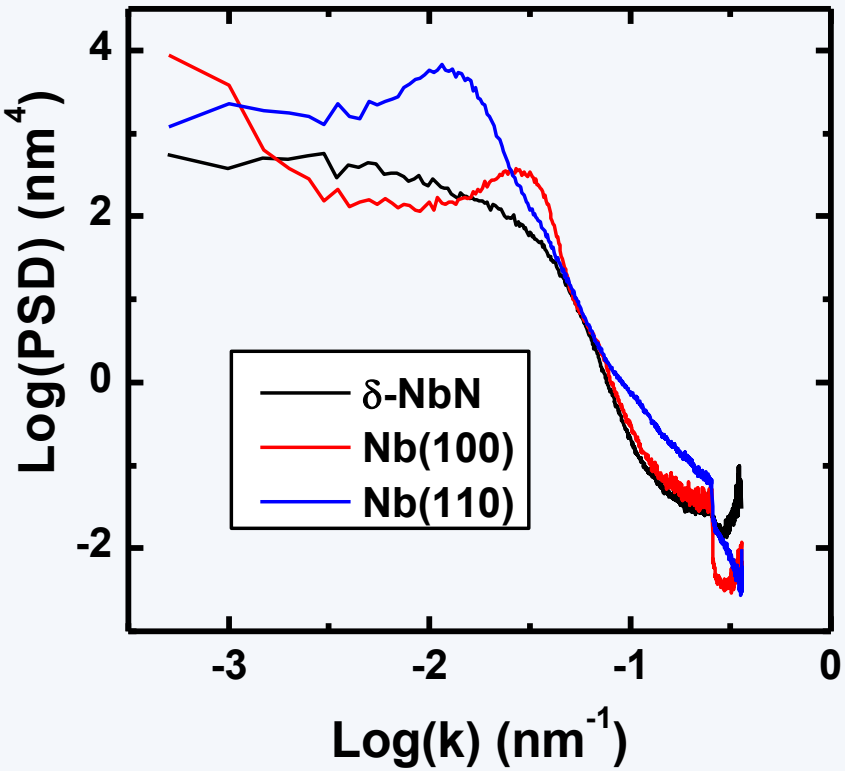


2D FFT



PSD





Peaks present in Nb PSD indicate wavelength selection and influence of step edge barrier

Absence of peaks for NbN PSD characteristic of self affine growth

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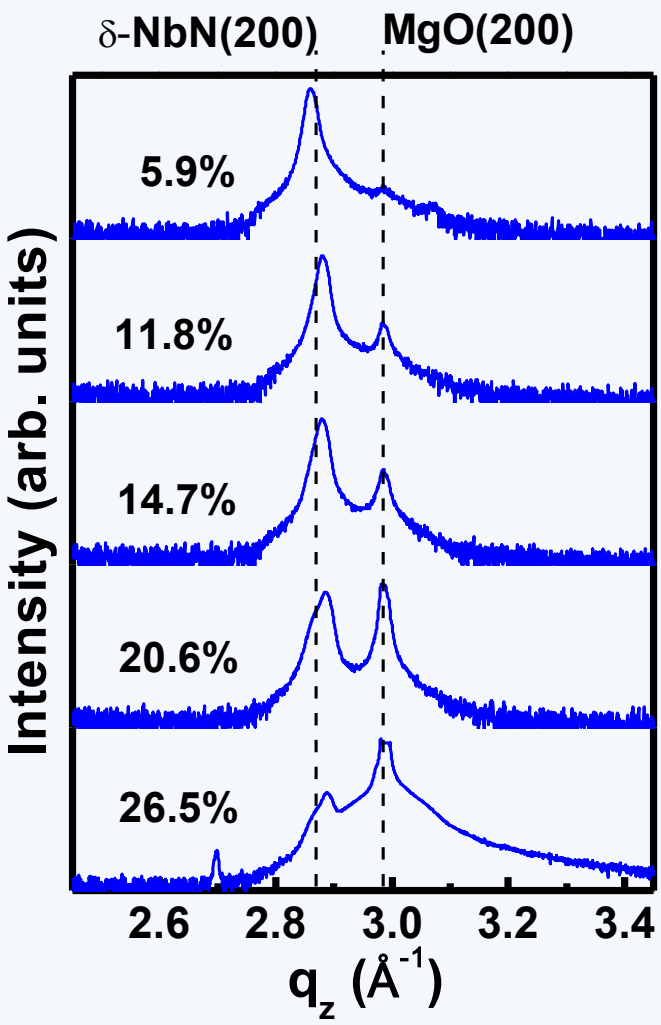
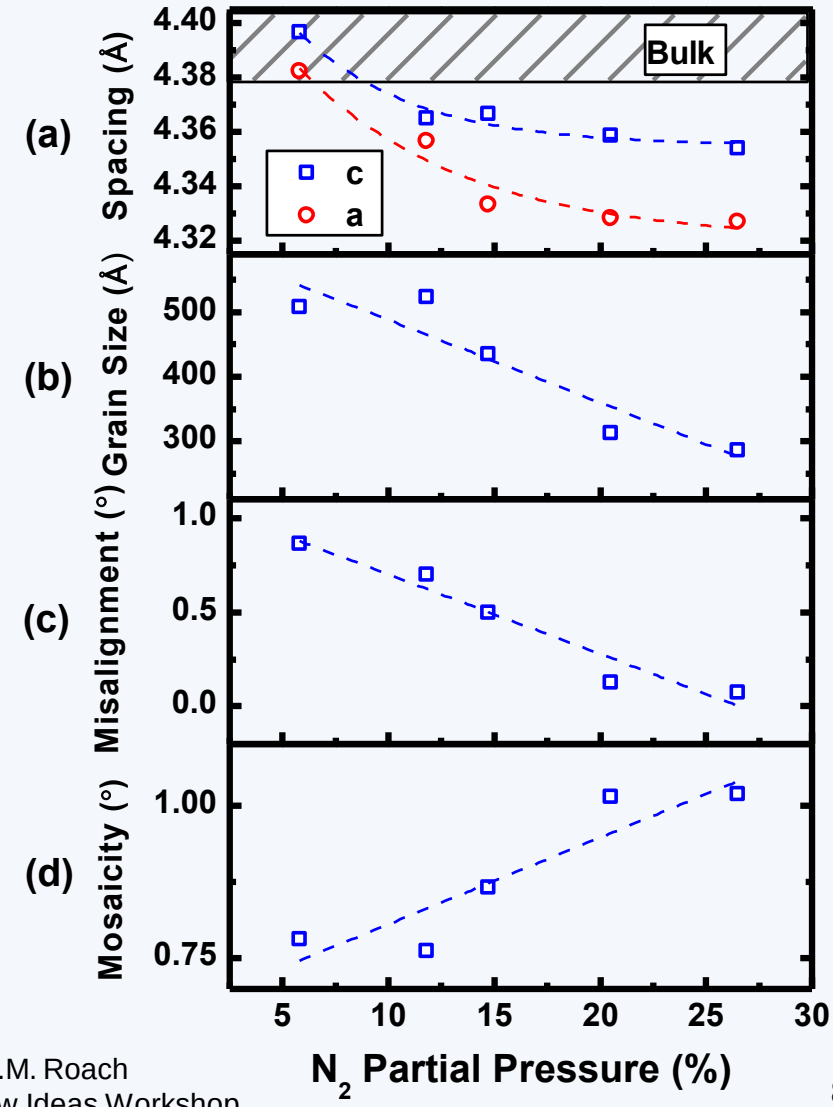
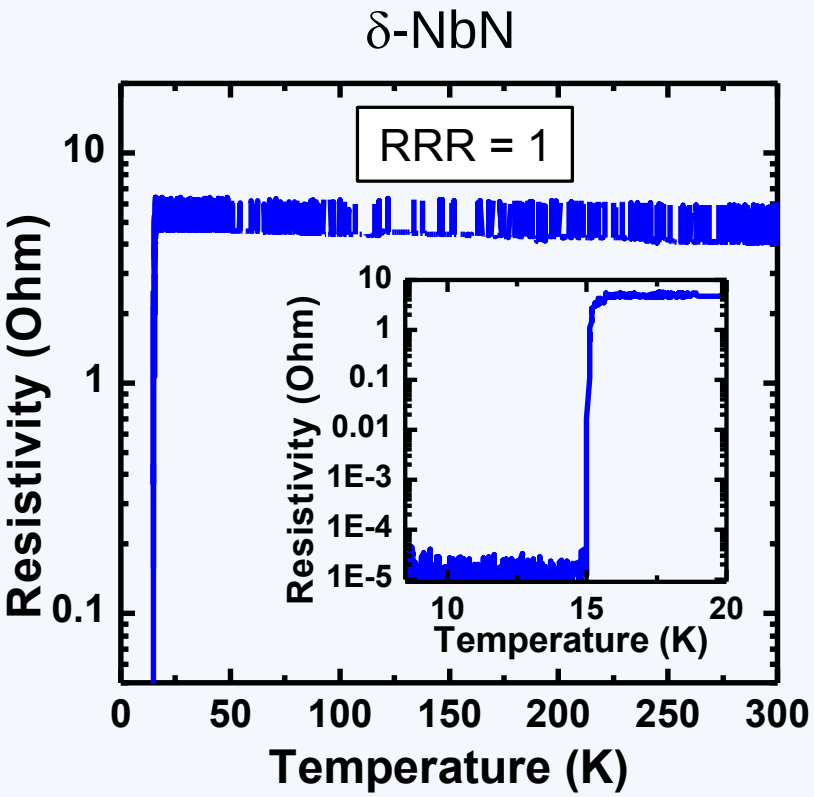
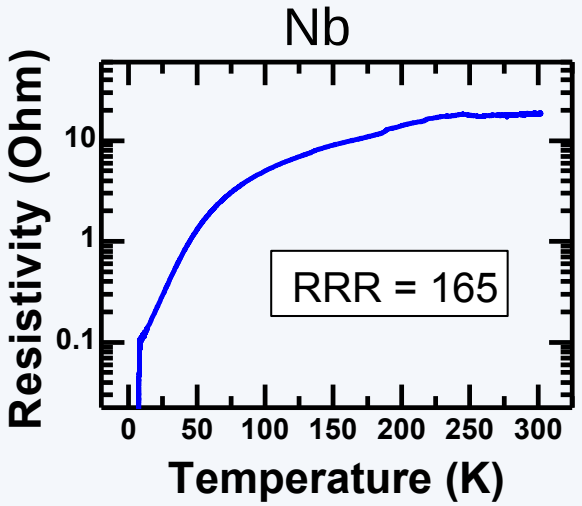
Film Structure





Residual Resistance Ratio





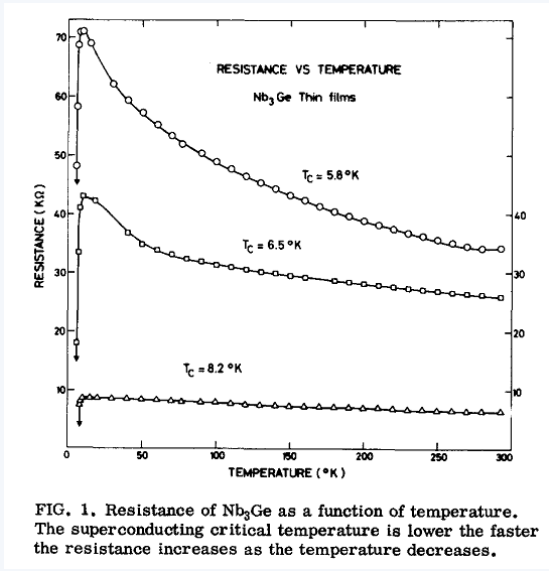
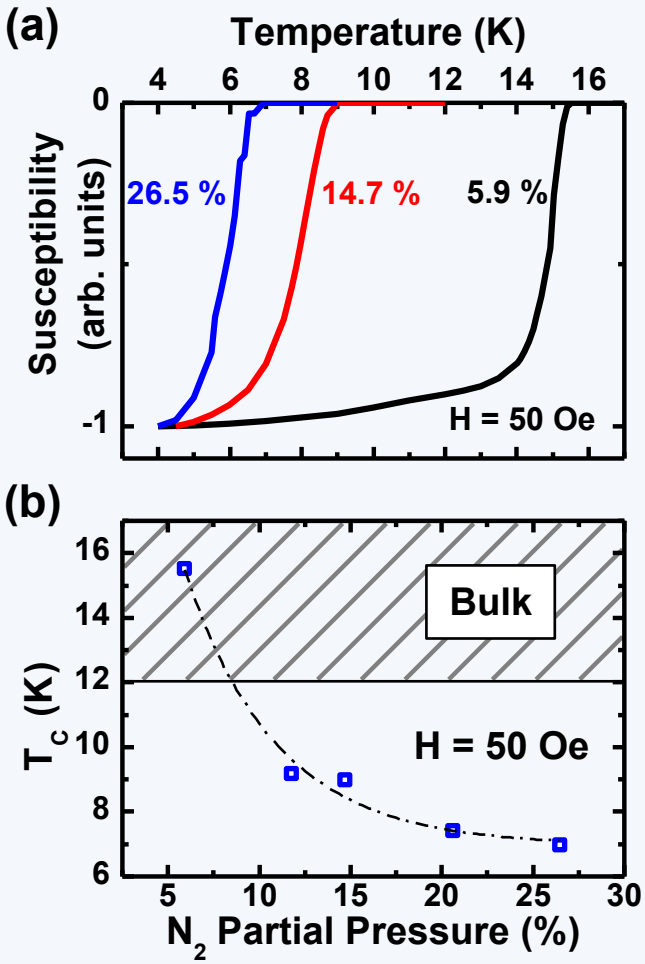


FIG. 1. Resistance of Nb_3Ge as a function of temperature. The superconducting critical temperature is lower the faster the resistance increases as the temperature decreases.

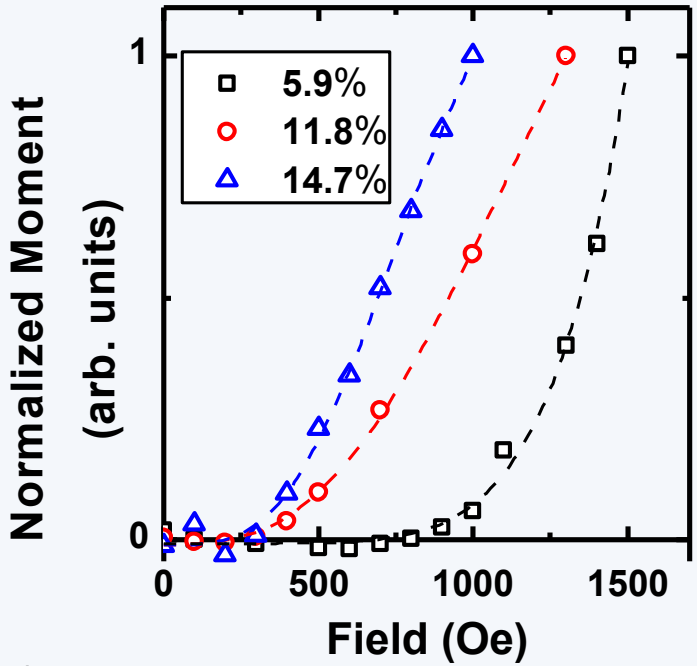
H. C. Jones, Appl. Phys. Lett. **27**, 471 (1975)

Superconducting Properties



H_{C1} determined by measuring trapped moments that appear after application and removal of $H \geq H_{C1}$

C. Böhmer, G. Brandstätter, and H. W. Weber, Supercond. Sci. Technol. **10** A1 (1997).



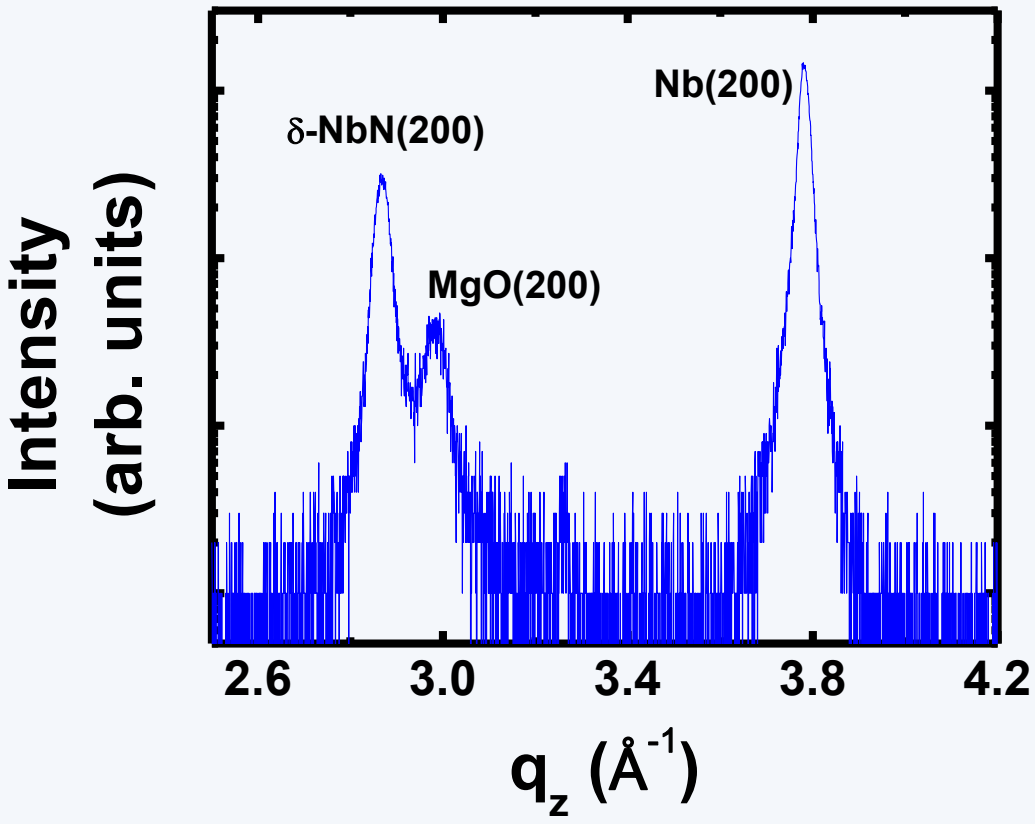
Multilayer Film

50 nm NbN

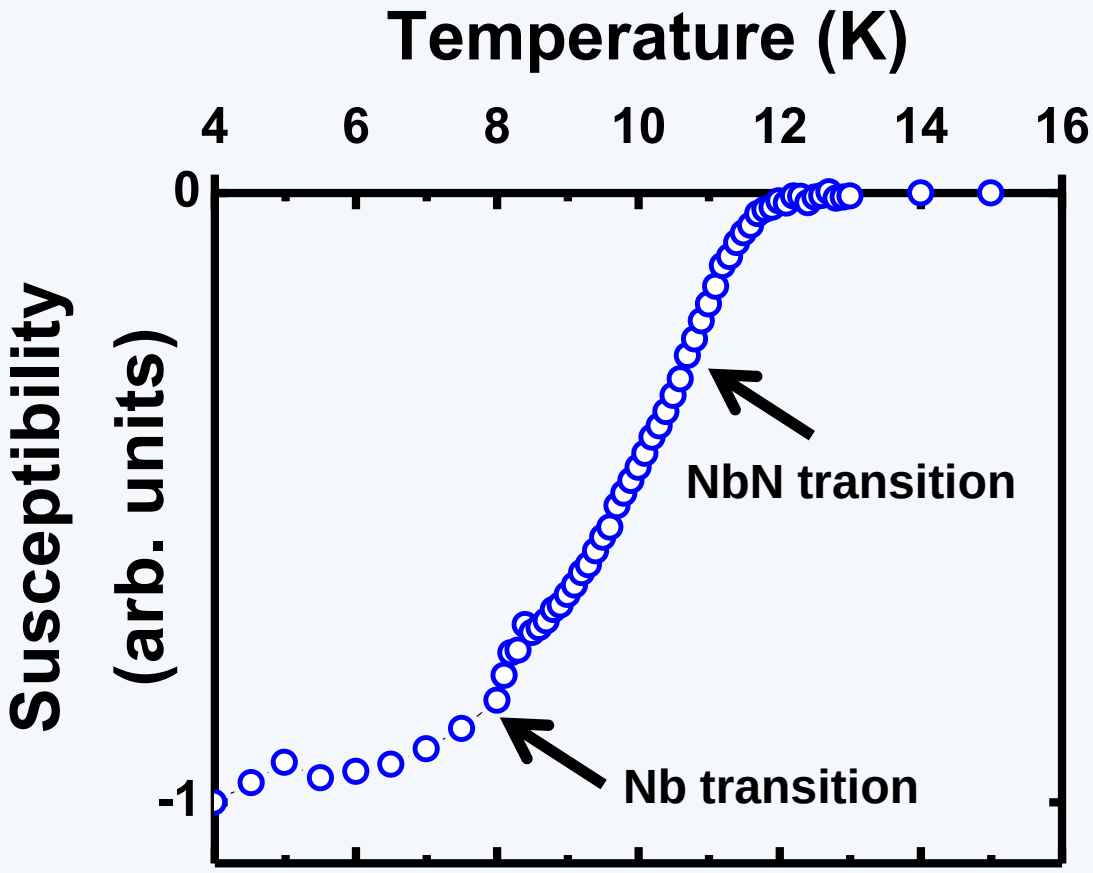
15 nm MgO

250 nm Nb

MgO (100)



Multilayer Film



- Further optimization
  - Surface modification (ion gun)
  - Alternative insulators (AlN)

Conclusion

- Produced high quality NbN films in ideal situation
- NbN differs from Nb in surface morphology and resistive behavior
- Multilayer optimization in progress
- RF measurements
- Investigate other materials