

ARIES Update – Small samples

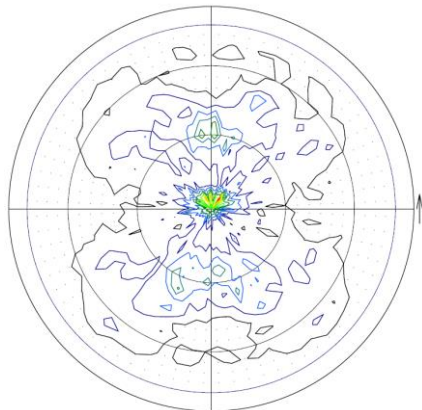
Stewart Leith, Bing Bai, Michael Vogel



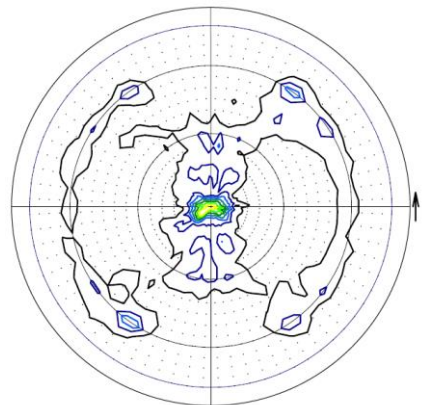
Authors would like to acknowledge the support provided by European Union's ARIES collaboration H2020 Research and Innovation Programme under Grant Agreement no. 730871.



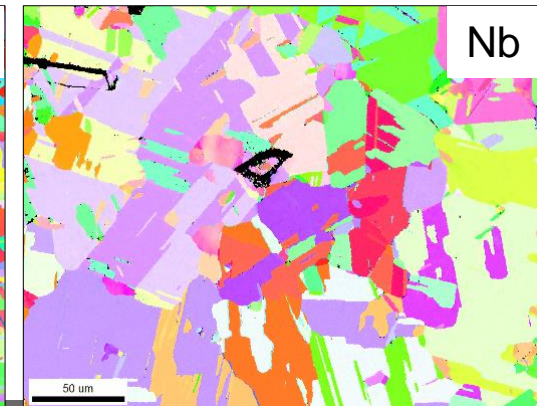
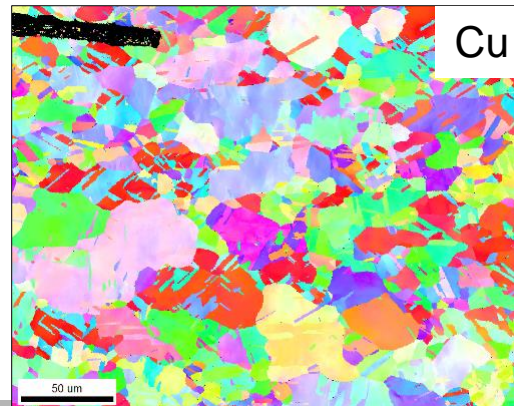
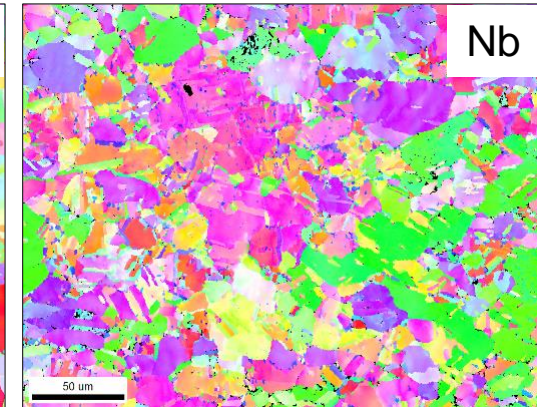
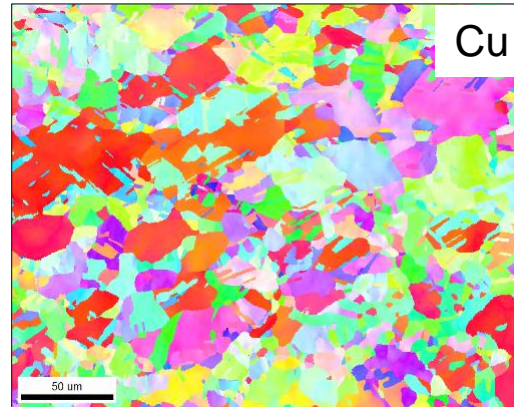
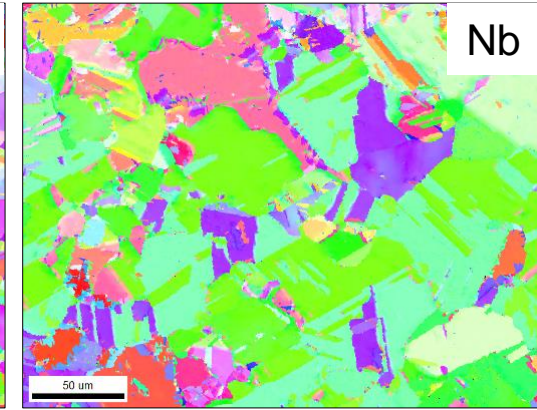
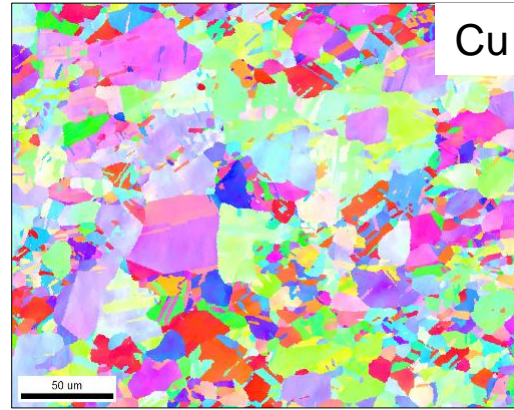
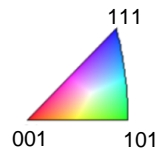
- PF indicates Nb (110) / Cu (100) growth regardless of deposition conditions. (As predicted by Spradlin *et al* , 2011)
- EBSD indicates polycrystalline film with no preferential growth on Cu



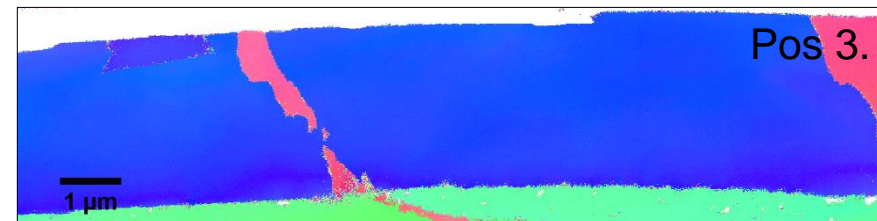
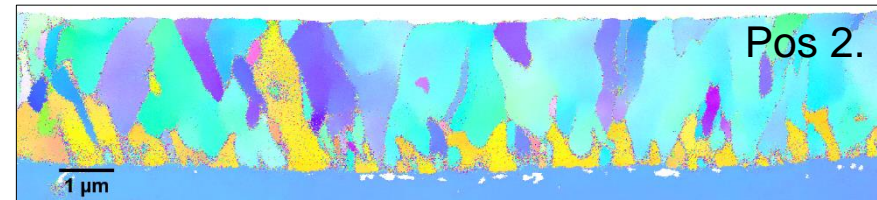
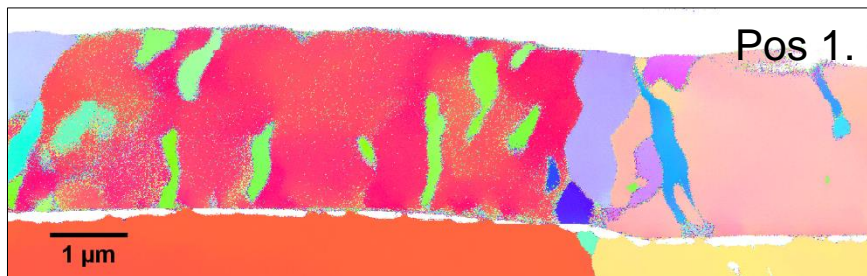
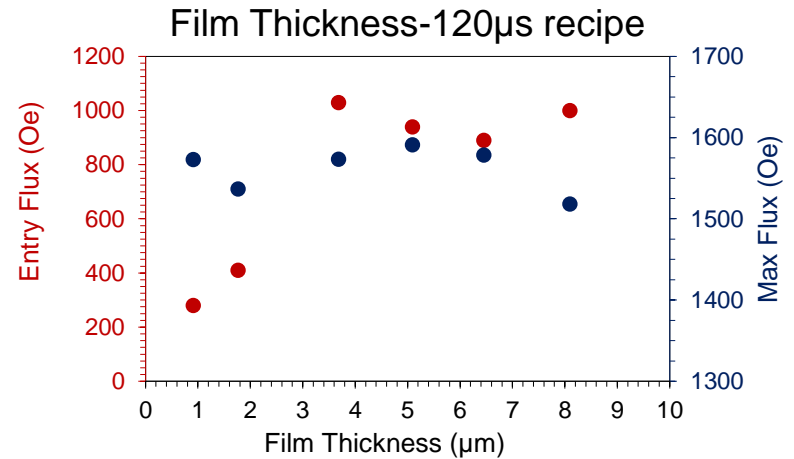
Cu (100)



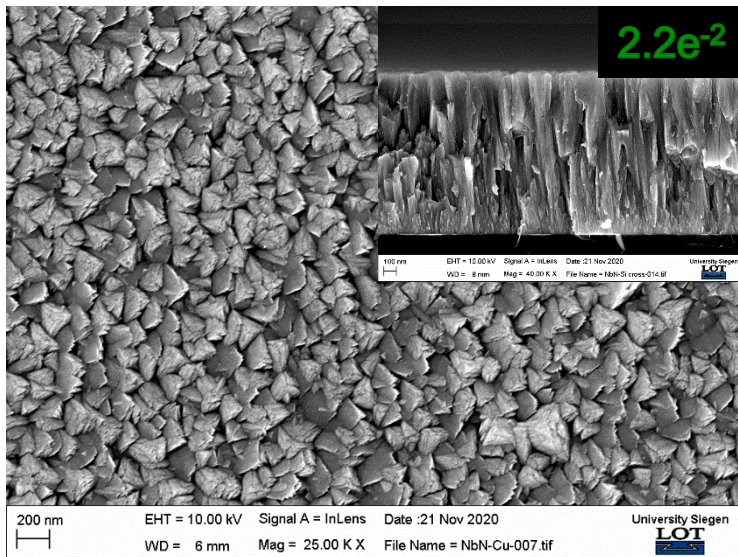
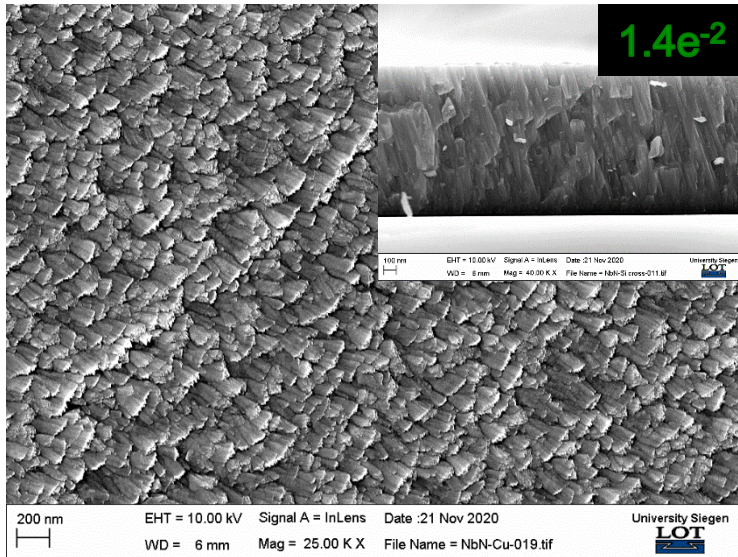
Nb (110)



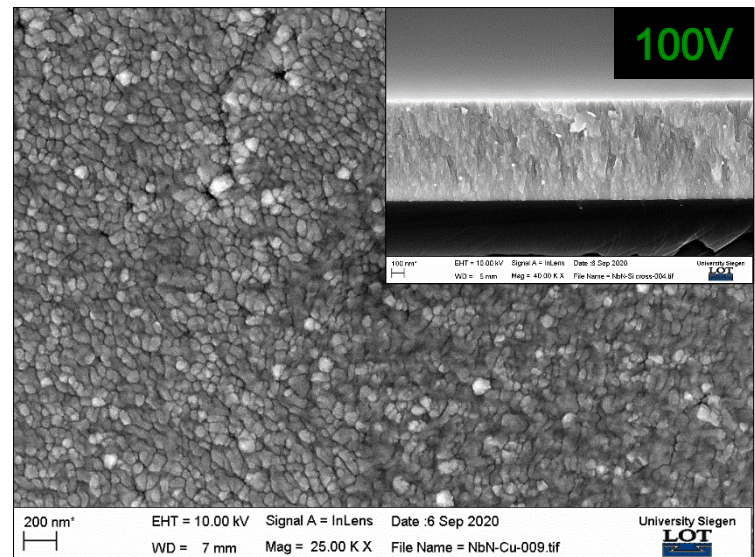
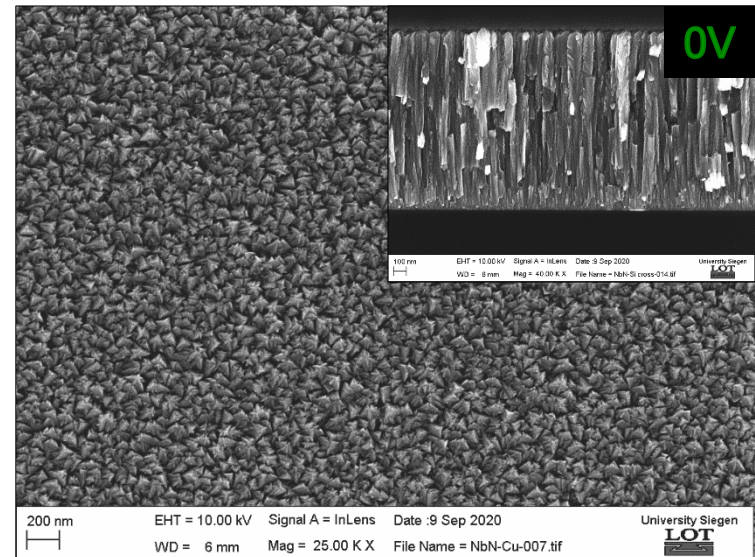
- Cross section EBSD attempted
 - Polishing results inconsistent
 - Possible redeposition of Cu onto polished position
- Resultant EBSD maps show differing film structure depending on Cu grain orientation
- Lack of Cu structure in Nb film structure evident via Pos.1
- “Transition Zone” (ca. $1\mu\text{m}$) visible at Pos. 2.
 - Correlates with previous H_{en} data.
- Large single grain in Pos. 3 not possible. Similar orientation of multiple grains more likely

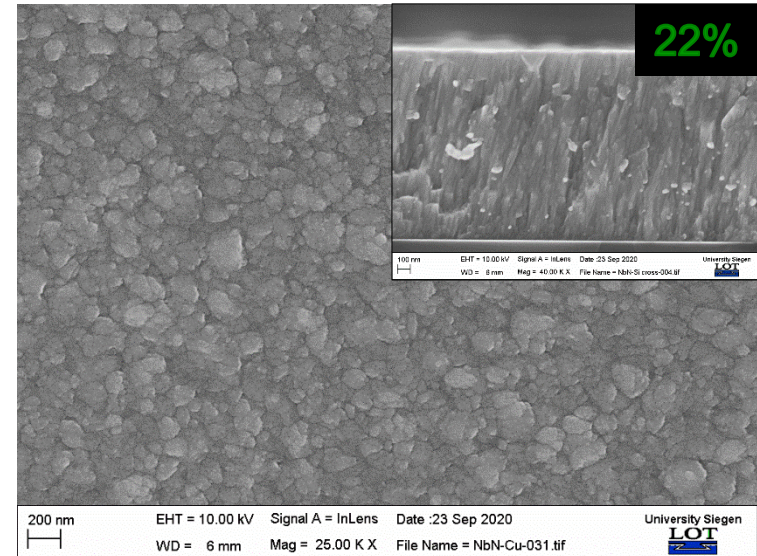
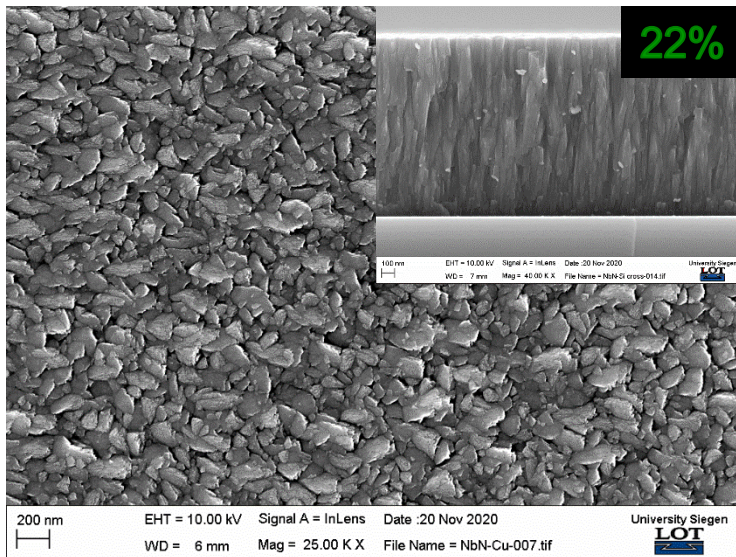
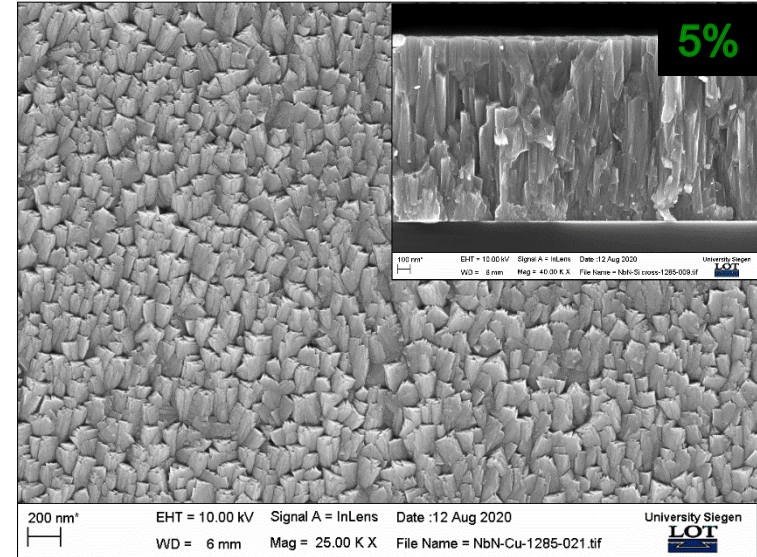
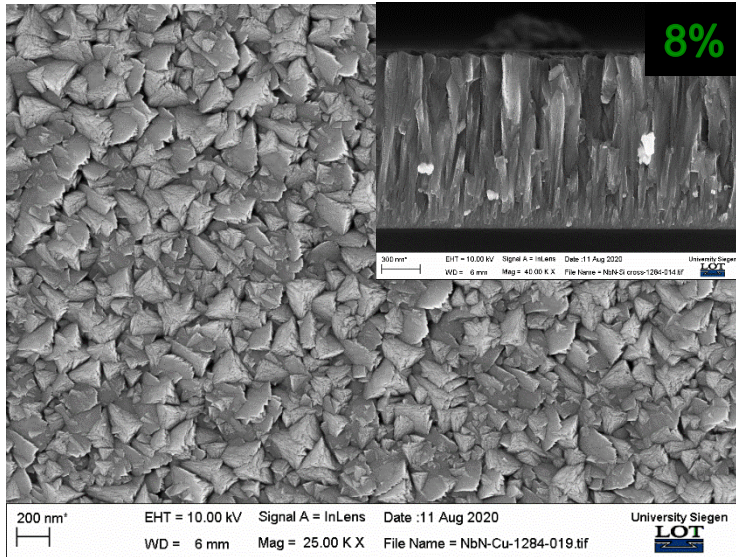


Deposition Pressure



Substrate Bias



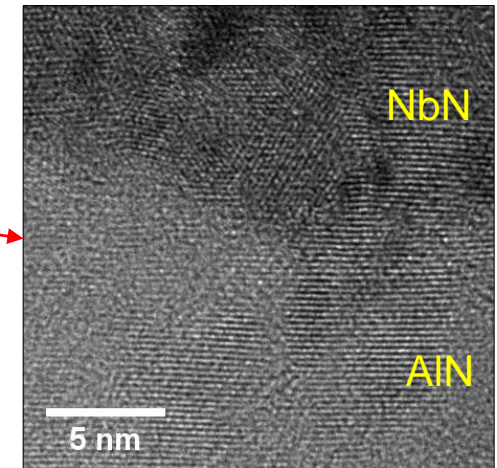
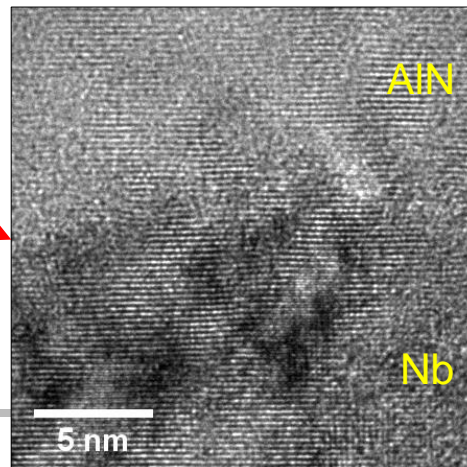
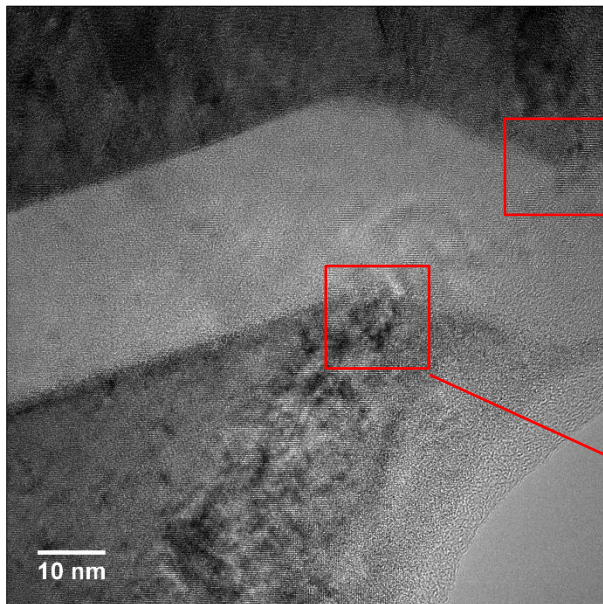
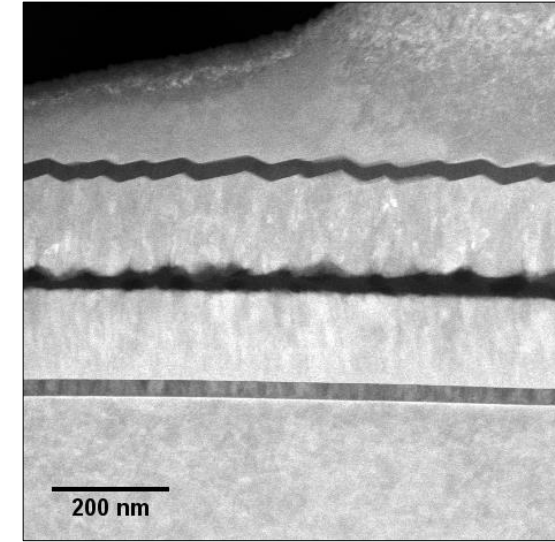
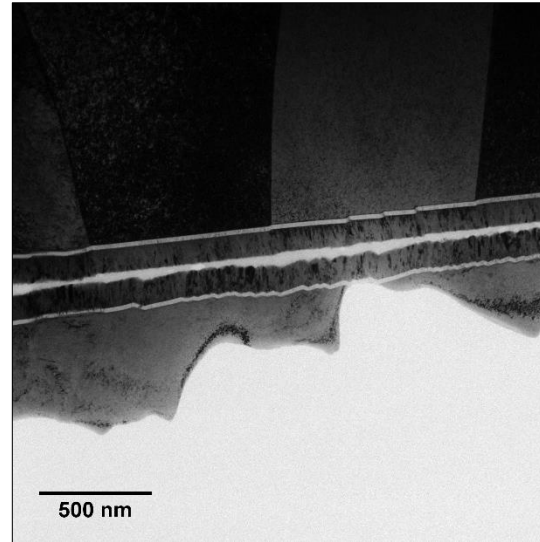


300W, $2.2e^{-2}$, 50V

400W, $2.2e^{-2}$, 50V

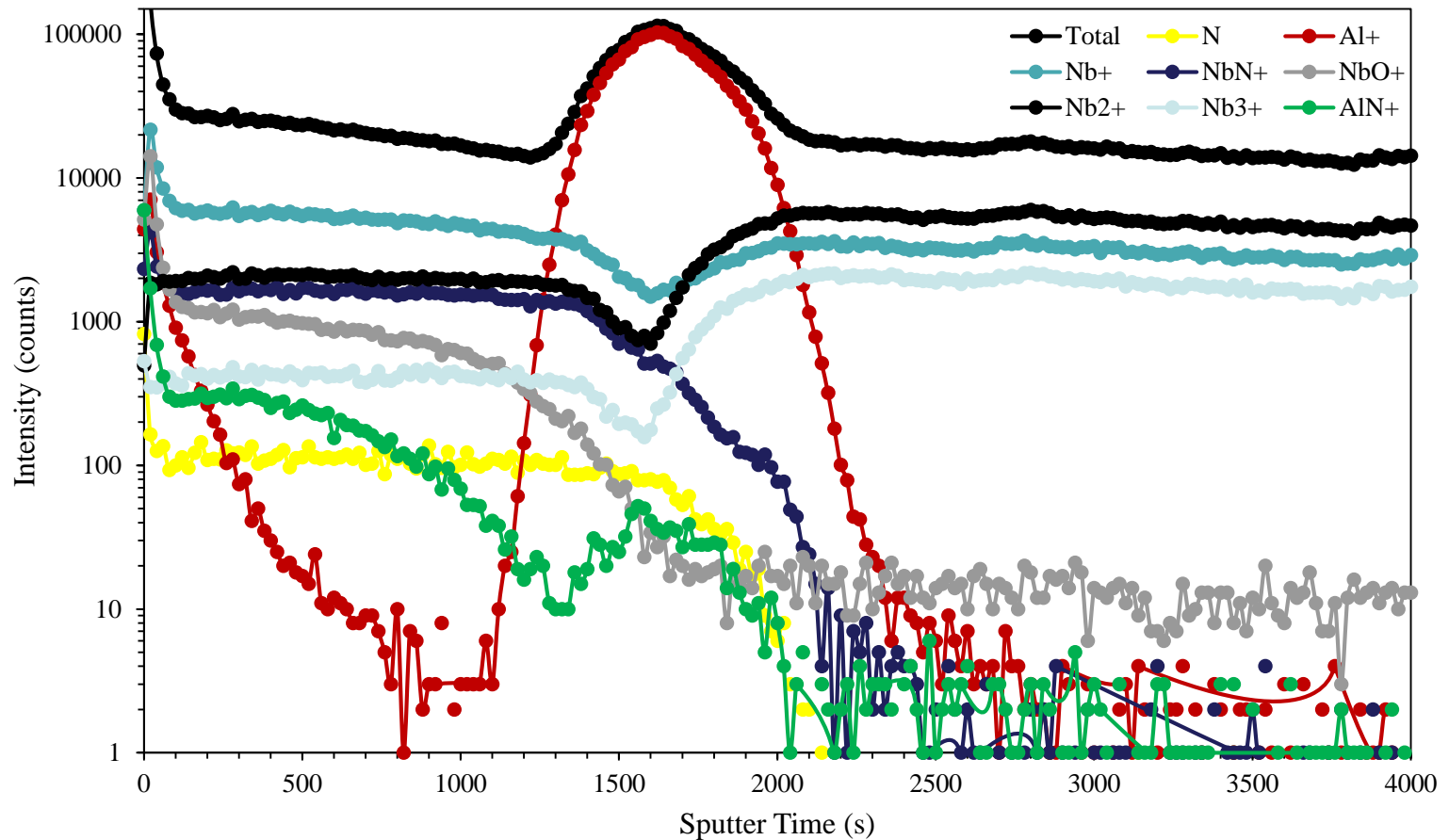
TEM investigation of best performing SIS film (HiPIMS Nb + DC MS NbN)

- Surface microstructure dependent on Nb/Cu base layer
- Interfaces display epitaxial relationship
- No voids present in ML structure



SIMS analysis completed in positive mode for a selection of ML samples

- Depth profiled through NbN, AlN and into Nb.
- Presence of O identified with NbO₂⁺ in NbN layer. Not in Nb



Next Steps

- Completion of HiPIMS NbN study with thickness test – H_{c1} enhancement check
- Superconducting analysis of HiPIMS NbN thin films and final HiPIMS SIS samples

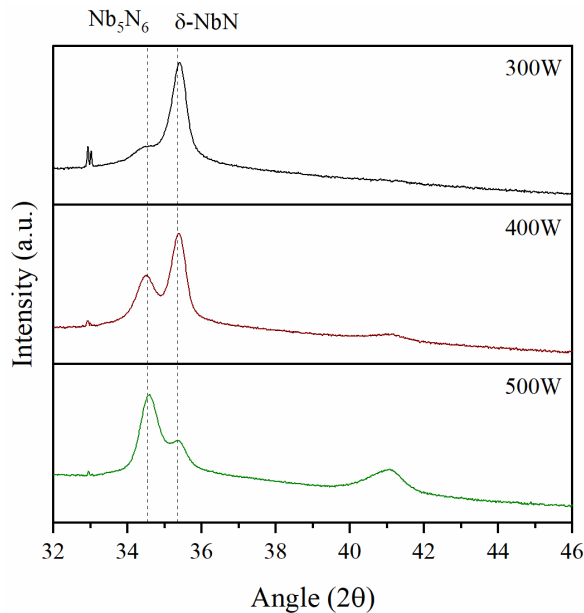
Thanks for your Attention!



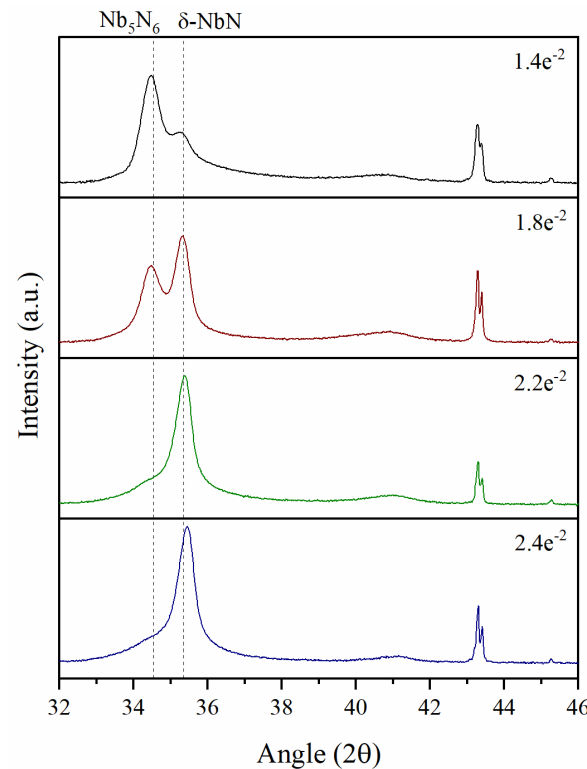
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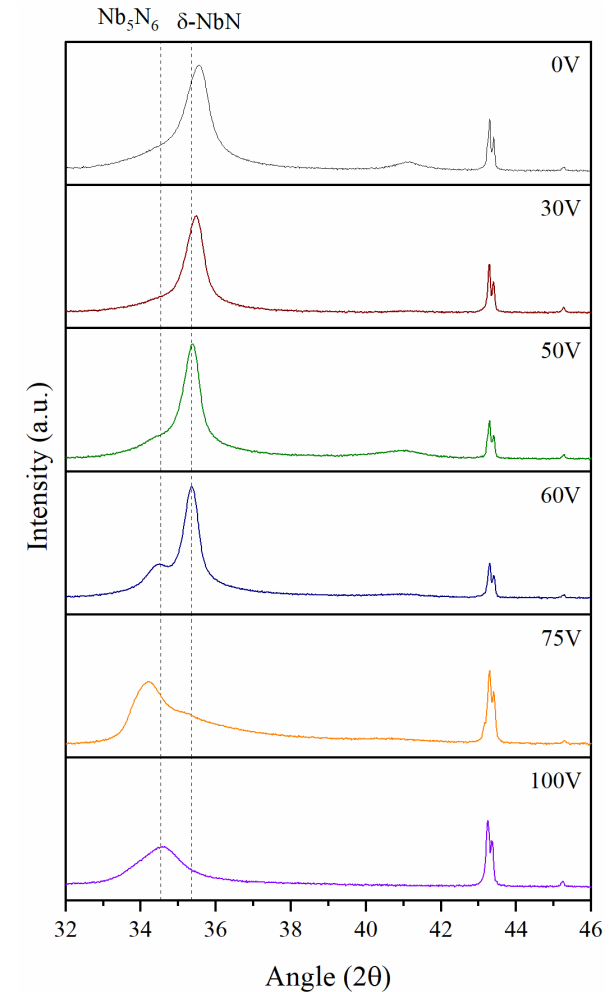
- New highest $T_c = 16.5K$. New highest $B_{en} = 28mT$ (more than double previous best)
- Largest influence in phase formation due to:
 - Cathode Power
 - Deposition Pressure
 - Substrate Bias
- Further samples deposited at: 300/400W, $2.2e^{-2}mbar$, 50V



Cathode Power ($2.2e^{-2}, 8\%$)



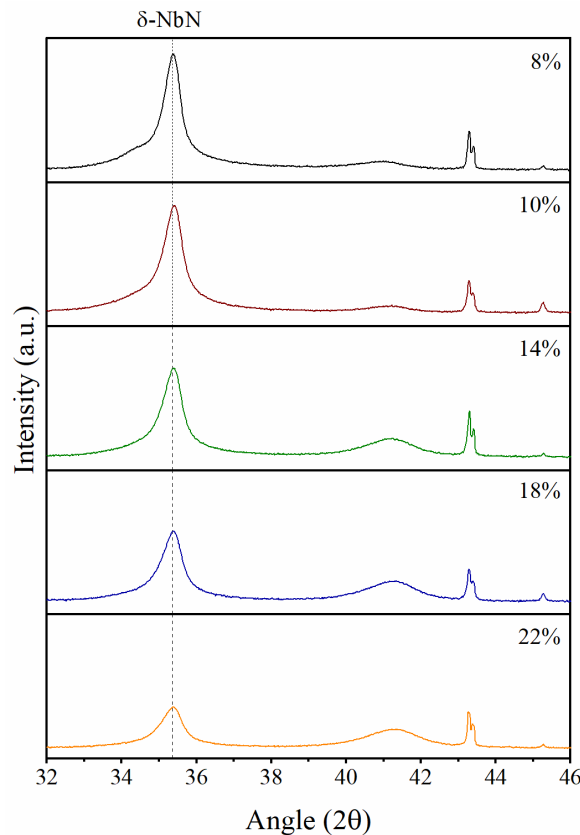
Deposition Pressure (300W, 8%)



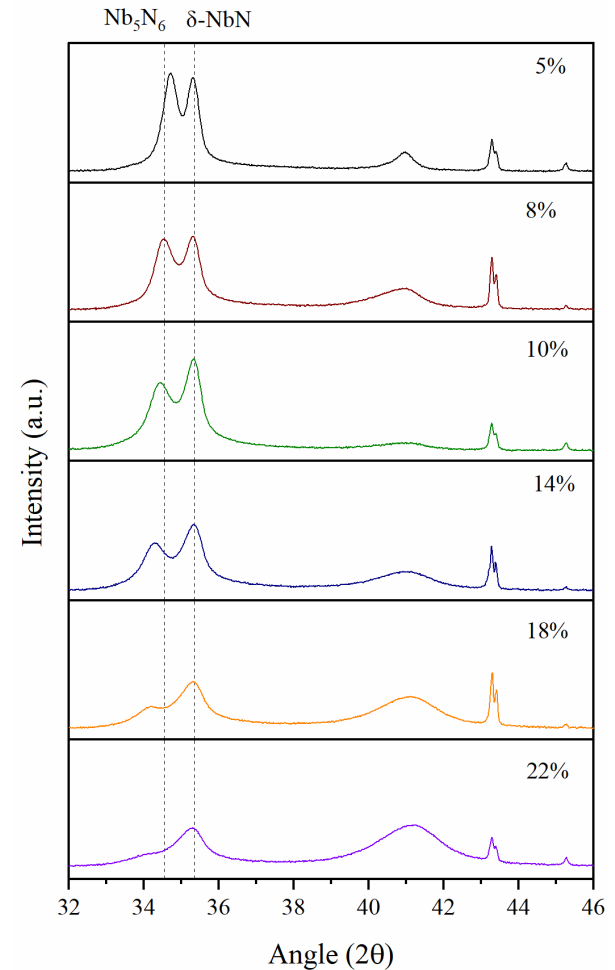
Substrate Bias (300W, $2.2e^{-2}$)

Samples deposited with varied $N_2\%$ at 300W and 400W

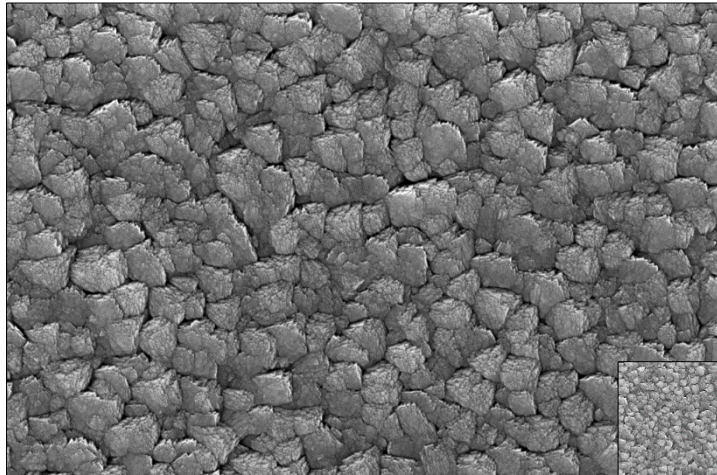
- Increase in $N_2\%$ leads to formation of (002) δ -NbN phase
- Phase change effects more pronounced at 400W



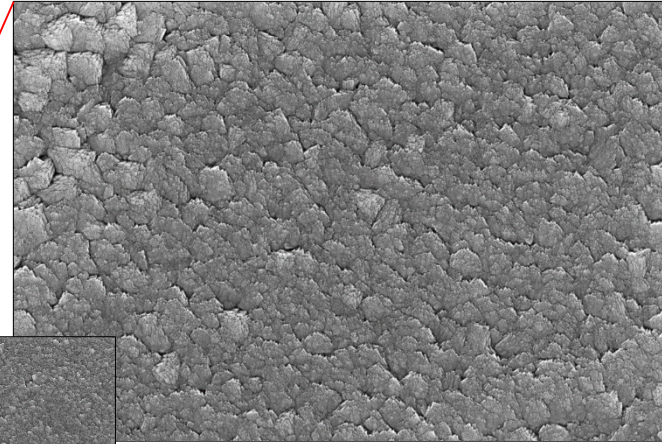
300W, $2.2e^{-2}$, 50V



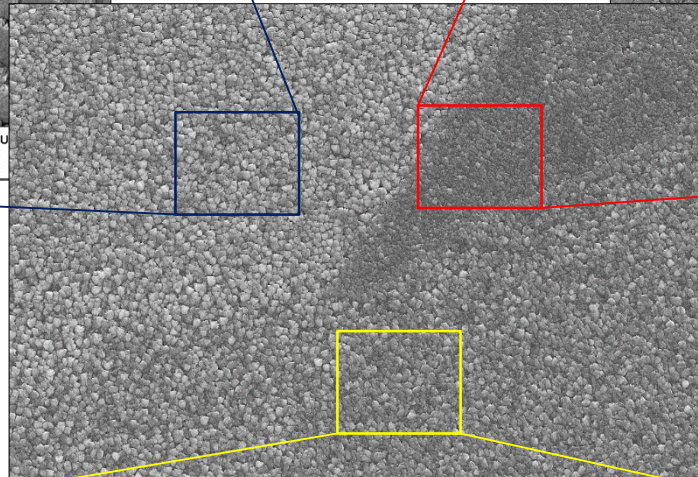
400W, $2.2e^{-2}$, 50V



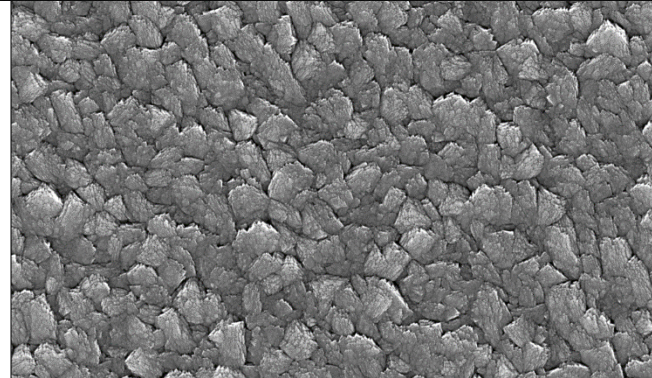
100 nm⁺ EHT = 10.00 kV Signal A = InLens Date :24 Nov 2020
WD = 7 mm Mag = 50.00 K X File Name = NbN-Cu-025.tif



EHT = 10.00 kV Signal A = InLens Date :24 Nov 2020
WD = 7 mm Mag = 50.00 K X File Name = NbN-Cu-021.tif



1 μm⁺ EHT = 10.00 kV Signal A = InLens Date :24 Nov 2020
WD = 7 mm Mag = 10.00 K X File Name = NbN-Cu-017.tif



100 nm⁺ EHT = 10.00 kV Signal A = InLens Date :24 Nov 2020
WD = 7 mm Mag = 50.00 K X File Name = NbN-Cu-029.tif