

Production of Superconducting Nb₃Sn and NbN thin films

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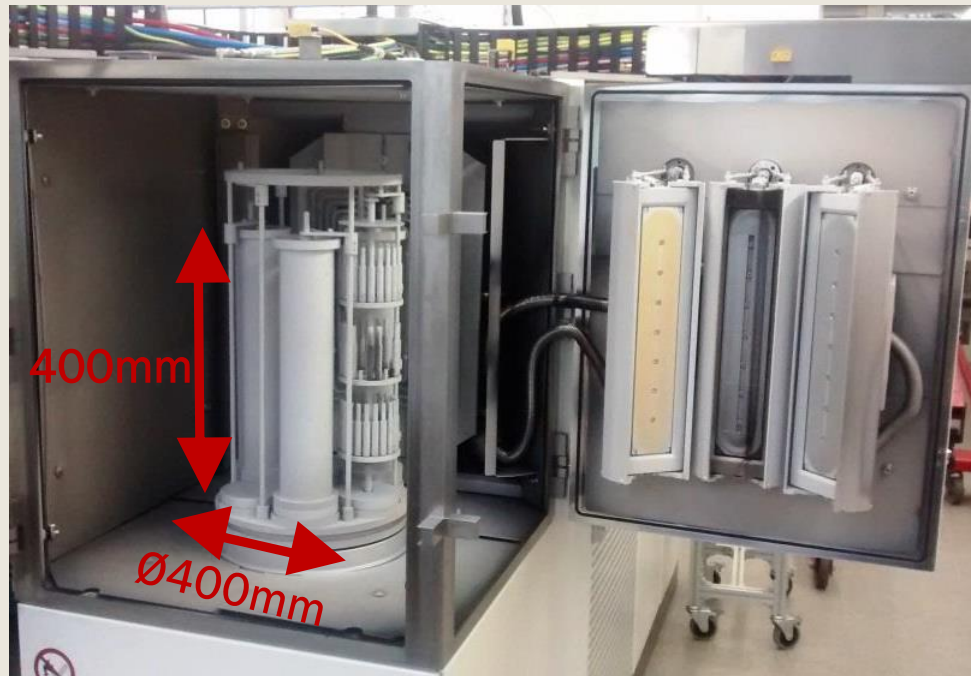


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Research Topic Description

1. Synthesis of low temperature superconducting thin-film coatings on copper substrates. Starting with Nb and then focus on A15 (Nb_3Sn) and B1 (NbN) type of materials.

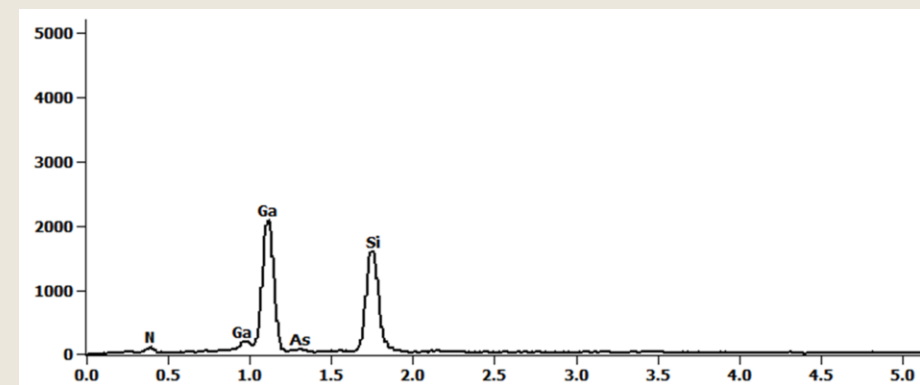
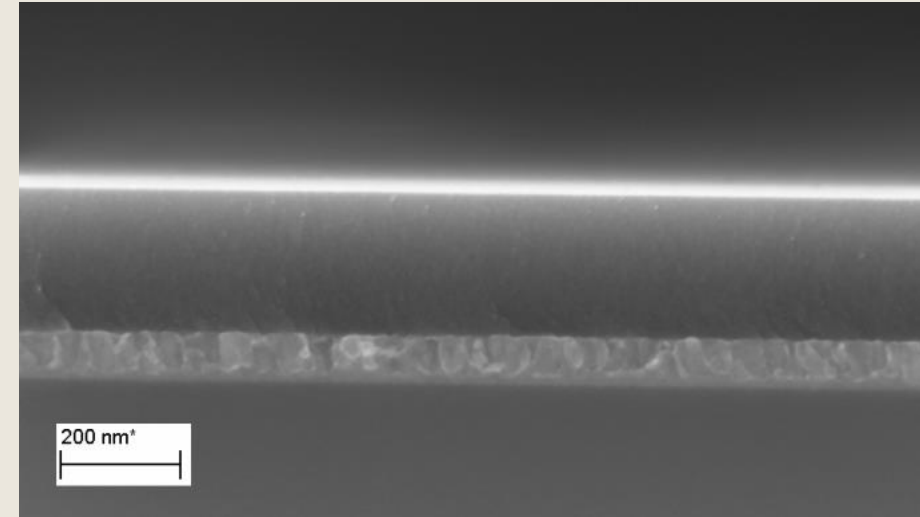
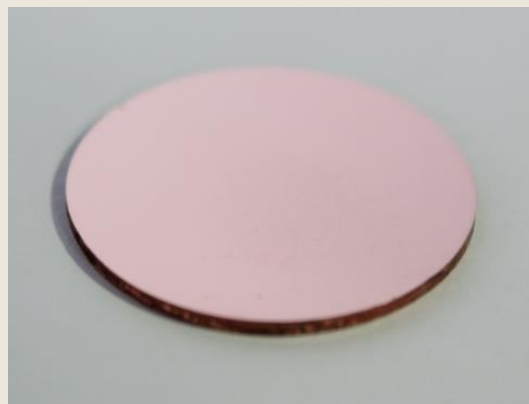


DC and HiPIMS
Cathodes



2. Production of a quality assessment matrix based on microstructural and electrical properties as a function of substrate type and substrate temperature.

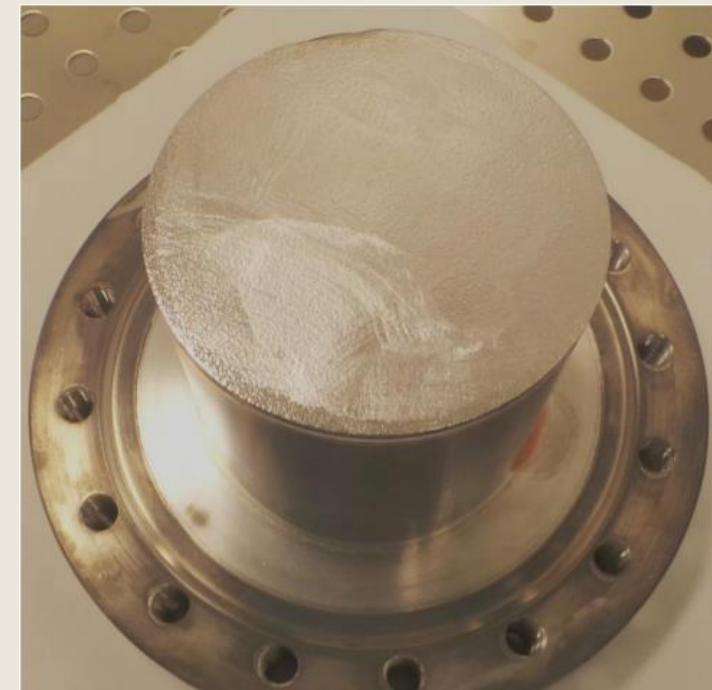
65mm Cu sample.



Research Topic Description

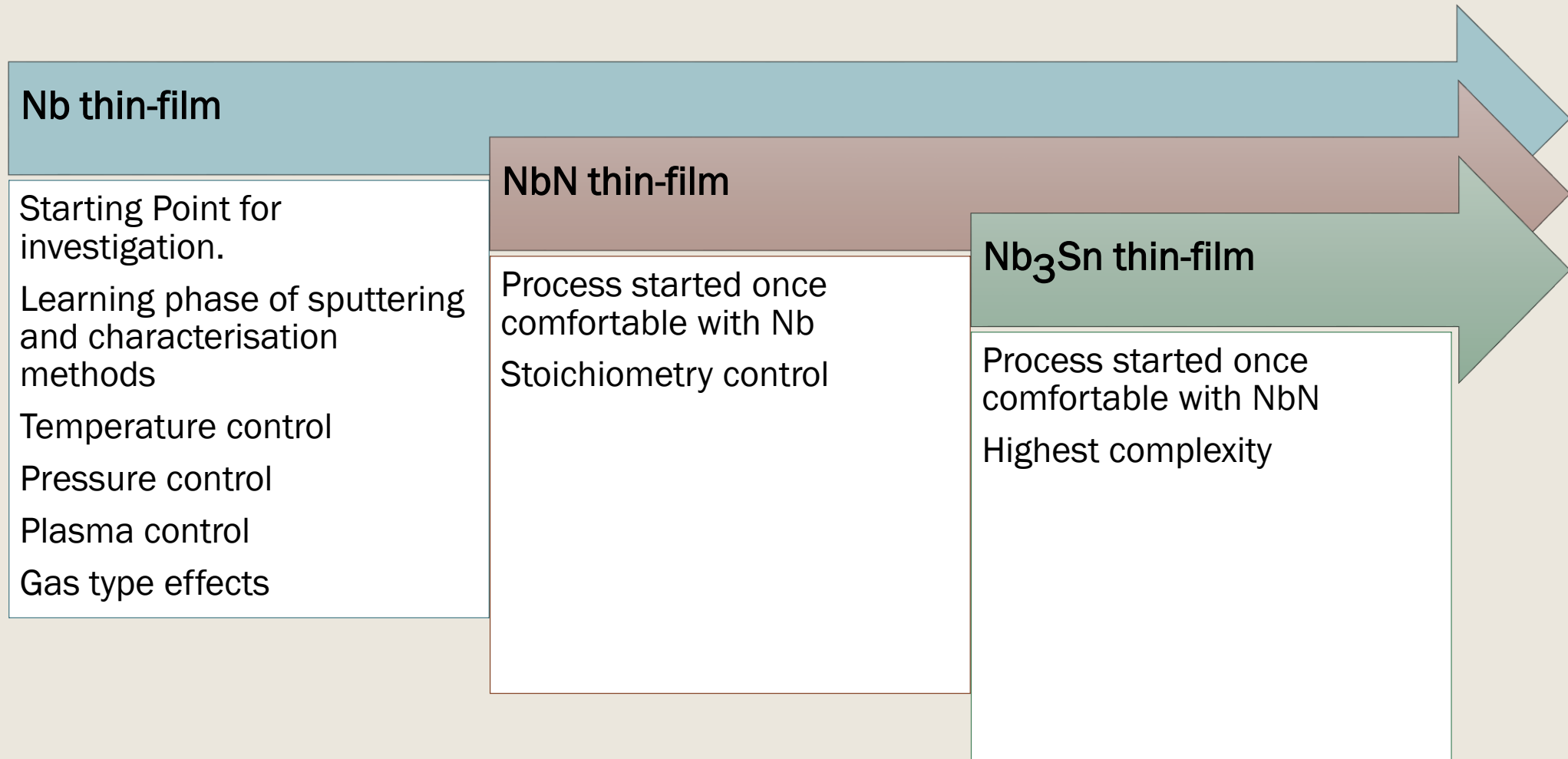
3. Optimisation of the synthesis process with respect to RF performance. Correlation of essential process parameters with the thin-film structure and its characteristics. RF characteristics will be determined by ESR 8 at HZB.

65mm diameter disk sample from HZB.



[3] O. Kugeler et al, Activities with the quadrupole resonator at HZB, Proceeding of the EuCARD-2 3 rd Annual WP12 Meeting (2016)

Work Plan



Sample Preparation

- OFE Copper
- Mechanical Polishing
- Chemical Polishing

Thin-Film Deposition

- Nb, NbN and Nb₃Sn
- Ar and Kr gas
- DC Magnetron and HiPIMS (High Power Impulse Magnetron Sputtering)

Sample Analysis

- SEM, XPS, FTIR, XRD, EDX, RRR
- EDX = Chemical Analysis
- SEM = Microstructural analysis
- RRR = Electrical Analysis

RF Characterisation

- Conducted at HZB by ESR 8
- Sample to be sized according to HZB requirements
- Provides feedback regarding deposition parameters

Intended Outcomes

- Improve and quantify substrate handling procedure and preparation process to obtain homogeneous coatings in a reproducible fashion (D3.1)
- Understanding of interdependencies of the synthesis process and parameters and how they affect the outcome of thin-film coatings (D3.2)
- Construction and utilisation of RRR (Residual Resistance Ratio) test setup
- Construction and use of dedicated high temperature thin-film synthesis system
- Document training contents concerning the synthesis of low-temperature superconducting thin-films (D5.2)

Challenges and mitigation strategies

- **Stoichiometry control:** Superconducting A15 phase is only prevalent in a small band of Sn % in Nb_3Sn and T_c for NbN is very dependent on Nitrogen stoichiometry.
- **Growth of grains:** Grains often tend to mimic the structure of the underlying substrate. Difficult to grow large grain sizes. Heated substrate surface aids in the growth of larger grains.
- **Residual Stresses:** Film peeling post sputtering due to residual stresses. Optimisation of sputtering pressure seen as key.
- **Inter-diffusion:** Diffusion of Cu into deposited thin-film at high temperatures. Intermediate layer could be deposited first to prevent this. Possibly Tantalum or Niobium. Requires investigation.
- **Differential expansion of Cu:** Under high temperatures, differential expansion of Cu and Nb_3Sn can lead to cracks in the thin film. Required to activate superconducting A15 phase.
- **Time-delay:** Possible time-delay between thin film deposition and RF characterisation at HZB. May lead to long lead times on adjusting parameters.

Status

- **Currently in the learning phase:** Sample preparation procedures, sputtering and microstructural analysis methods to be learnt in parallel. Just begun.
- **Initial samples foreseen as soon as possible:** The production of worthwhile samples will take some time due to the learning curve. Initial preliminary samples to be produced soon as part of the learning process.

Ngiyabonga!

Thank You!

