AKBP 9: RF Cavities I

Time: Wednesday 11:00–12:30 Location: SCH/A117

AKBP 9.1 Wed 11:00 SCH/A117

RF characterization of superconducting samples with the UHH QPR at DESY — •Carl Weiss[1], Ricardo Monroy-Villa[2], Manuela Schmökel[3], Marc Wenskat[1,3], and Wolfgang Hillert[1] — [1]Institut für Experimentalphysik, Universität Hamburg — [2]Institut für Kernphysik, Johannes Gutenberg-Universität Mainz — [3]Deutsches Elektronen-Synchrotron DESY

Superconducting materials are indispensable for modern accelerators, for example highest acceleration fields are achieved with superconducting radio-frequency cavities made out of niobium. To further advance the development of superconducting materials for accelerators, an RF testing of samples is essential. The quadrupole resonator (QPR) is such a testing system, which allows the RF characterization of samples in the range of typical operational parameters of accelerators, such as a temperature range of 2-20 K, magnetic fields up to 120mT and for three different frequencies: 425 MHz, 860 MHz and 1300 MHz. In this report, the very first measurement of a sample in two different QPRs will be reported, which will proof the reliability and accuracy of such a system. Furthermore, fully exploiting the fact that the very same surface is tested at three different frequencies, the slow vs. fast superconductor model and non-equilibrium superconductivity will be investigated. This is of significant importance to study the so-called mid-T recipe developed for 1.3 GHz and test its transferability to other frequencies.

AKBP 9.2 Wed 11:15 SCH/A117

Atomic layer deposition of silicon nitride as an insulator layer for use in multilayer coating of cavities — •Ana Katharina Steffens[1], Isabel Díaz-Palacio[1], Robert Zierold[1], Marc Wenskat[2], and Wolfgang Hillert[1] — [1]Universität Hamburg, Hamburg, Deutschland — [2]Deutsches Elektronen Synchrotron (DESY), Hamburg, Deutschland

Multilayer coatings of superconducting cavities provide a strategic route to superconducting radio frequency surfaces engineered to surpass the performance limits of conventional bulk Nb. Particular attention is paid to SIS structures consisting of thin superconducting (S) and insulating layers (I), as these can prevent global vortex penetration and allowing for higher surface magnetic fields before the loss of the Meissner state. However, previous SIS structures consisting of Nb bulk, AlN, and NbTiN show diffusion of aluminum into the NbTiN layer upon annealing at high temperatures, compromising the SIS-performance. Herein, SiN is investigated as an alternative due to its greater thermal stability. Plasma-enhanced atomic layer deposition (PEALD) is used to deposit thin SiN and NbTiN layers, enabling controlled growth of homogeneous, conformal layers at low process temperatures. This study focuses on the development of a PEALD process for SiN and the characterization of various layer configurations, with initial results being presented.

AKBP 9.3 Wed 11:30 SCH/A117

Comparison of co-sputtered Nb_3Sn thin films grown on copper, sapphire and fused silica — •Amir Farhood[1], Alexey Arzumanov[1], Márton Major[1], Mohammad Khodakarami[1], Amin Matin Javid[1], Michaela Arnold[2], Norbert Pietralla[2], and Lambert Alff[1] — [1]Institute of Materials Science, Technical University of Darmstadt, — [2]Institute of Nuclear Physics, Technical University of Darmstadt, Darmstadt, Germany

Pure Niobium is still the main choice for superconducting RF cavities; however, it must be operated at around 2 K, which significantly increases cooling requirements. Nb_3Sn with a much higher T_c of approximately 18.2 K enables operation at 4.2 K. Applying Nb_3Sn coatings onto copper cavities through co-sputtering is expected to enhance the quality factor and to suppress quenching at elevated accelerating fields. In this work, Nb_3Sn layers were co-sputtered onto different substrates to examine their critical temperature and lower critical field (H_{c1}). Film growth was carried out under controlled conditions, followed by characterization through X-ray diffraction, resistivity measurements, and SQUID magnetometer. On all substrates, Nb_3Sn exhibits a clear superconducting transition. For films deposited on r-cut sapphire, a T_c of 17.8 K was achieved, which is close to the value for bulk Nb_3Sn. On copper, the films showed a T_c of about 15 K. Importantly, H_{c1} exceeded not only that of bulk Nb_3Sn but also that of pure niobium.

AKBP 9.4 Wed 11:45 SCH/A117

Texture investigations of Nb_3Sn thin films grown for SRF cavity application — •Márton Major[1], Alexey Arzumanov[1], Amir Farhood[1], Michaela Arnold[2], Norbert Pietralla[2], and Lambert Alff[1] — [1]Institute of Materials Science, Technical University of Darmstadt, Darmstadt, Germany — [2]Institute of Nuclear Physics, Technical University of Darmstadt, Darmstadt, Germany

Superconducting (SC) RF cavity technology is dominated by bulk Nb due to its proven physical performance and mature production technology. Needs for reducing the energy consumption of particle accelerators, however, call for alternative SC materials, such as Nb_3Sn, to allow their operation at higher temperatures at lower cryogenic costs. The Nb_3Sn coating of carrier structures has the potential to reach high acceleration gradients even at 4.2 K. Utilising thin film technology enables to use copper, an excellent heat conductor, for the bulk of the cavity to which Nb_3Sn can be sputtered for high-quality SC coatings. At our group, based on a low-temperature magnetron co-sputtering process, the direct deposition of SC Nb_3Sn on Cu became possible. The grown films had high critical fields and critical temperatures. Films co-sputtered on different substrates (single crystalline sapphire, polycrystalline copper, amorphous glass) show different superconducting properties. In this contribution we present a detailed analysis of the texture and local order of the grown Nb_3Sn thin films based mainly on x-ray diffraction measurements and discuss possible causes of observed differences.

AKBP 9.5 Wed 12:00 SCH/A117

Successfull Refurbishment of TESLA Cavities for MESA — •Paul Plattner — JGU Mainz - Institut für Kernphysik, Mainz, Germany

Two TESLA cavities that were previously operated in the decommissioned ALICE project have been successfully refurbished in the clean room and tested at the AMTF. They now meet the requirements for the Mainz Energy-recovering Siperconducting Accelerator (MESA) and will be used to test Higher Order Mode (HOM) antenna upgrades for the MESA Energy Recovering (ER) mode.

AKBP 9.6 Wed 12:15 SCH/A117

V-Band Microwave Cavities for Pulse Compression in an Ultrafast Transmission Electron Microscope — •Johann Toyfl[1,2], Dennis Naraschkewitz-Epp[1,2], Armin Feist[1,2], and Claus Ropers[1,2] — [1]Department of Ultrafast Dynamics, Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — [2]4th Physical Institute, University of Göttingen, Göttingen, Germany

Ultrashort electron bunches are a unique source of coherent radiation, but utilizing their short matter wavelength for nanoscale probing was only recently achieved in ultrafast electron microscopes (UEM). However, their temporal resolution is typically limited by electron pulse dispersion to a few hundred femtoseconds [1].

In this contribution, we explore high-frequency V-band microwave cavities to compress the longitudinal phase space of electron pulses generated by femtosecond photoemission, either in the temporal or energy domain [1, 2, 3]. We characterize the microwave reflection coefficient and use our ultrafast transmission electron microscope (UTEM) [1] to obtain electric-field maps by spectroscopic imaging.

The integration of cavity-based phase-space control will enhance the temporal and spectral resolution of UEM, enabling the study of ultrafast dynamics that are currently accessible only in large-scale free-electron laser facilities.

[1] A. Feist *et al.*, Ultramicroscopy **176**, 63 (2017) [2] T. van Oudheusden *et al.*, Phys. Rev. Lett. **105**, 264801 (2010) [3] R. P. Chatelain *et al.*, Appl. Phys. Lett. **101**, 081901 (2012) [4] J. Kuttruff *et al.*, Sci. Adv. **10**, eadl6543 (2024)