Seminar

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Institute for Plasma Research

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Title:	Metalorganic Chemical Vapor Deposition of REBCO on various substrates and correlation of its superconducting properties for high frequency and functional applications
Speaker:	Dr. Rohit Jain High Temperature Superconductors Inc., California
Date:	09th December 2024 (Monday)
Time:	03:30 PM
Venue:	Join the talk online https://meet.google.com/rmv-wjet-meq?authuser=0

Abstract

Rare Earth Barium Copper Oxide (REBCO, RE-$Ba_2Cu_3O_{7-\delta}$) coated conductors (CC) are the only superconductors with a potential for direct current (DC) applications over broad range of temperature (77 K – 4.2 K) and wide range of magnetic fields (0 – 20 T). This makes them representative in various domains such as Power, Energy, and Medicine. In the electrical power domain, they are utilized in power cables, transformers, generators, and motors. High critical current density (J_c) of REBCO CC can be leveraged to generate strong magnetic fields, opening up pathways for use in high-energy particle accelerators, nuclear fusion reactors, superconducting magnetic energy storage devices and MRI magnets.

Development of long length REBCO CC is demonstrated using a Pilot A-MOCVD tool utilizing ohmic heating yielding 2x performance as compared to current commercial HTS companies. While scaling up the REBCO deposition process, certain engineering bottlenecks were resolved- Arcing and Dropout events. Critical Currents (I_c) > 1000 A/12 mm @ 77 K over 50 m length with film thickness of 4 μm, in a single pass has been achieved. A key feature of the Pilot A-MOCVD setup is inline monitoring by 2D-XRD. Crystallographic structure and J_c correlations & predictions has been devised to provide process feed-back. Additionally, an investigation using General Area Detector Diffraction System (GADDS) in predicting the film composition, lattice strain, and superconducting properties of 5% Zr-doped REBCO thin films is conducted with the end aim of practical applications. This project culminated with development of an electric motor and several HTS cables to be used in various functional applications.

Apart from DC applications, REBCO can be used in microwave applications owing to its low surface resistance (R_s). Applications such as resonators, microstrip-lines, microwave circuits, band-pass filters, radiation detectors and superconducting quantum interference devices (SQUID) fall into this category. To curtail losses at radio frequency (RF), it is critical to grow REBCO over dielectric substrates rather than metallic substrates as in CC.

We demonstrate REBCO growth over one such substrate Y_2O_3-stabilized ZrO_2 (YSZ) using MOCVD. Sample uniformity along width was improved by modification of showerhead design. Superior Q-factor of >44000 (@ 25 K, 9.4 GHz) and J_c > 1 MA/cm^2 (@77 K) have been achieved. Homogeneous REBCO

growth was confirmed using scanning hall probe microscopy (SHPM) over sample length with uniformity in $J_c \sim 13\%$. Key MOCVD process parameters such as heater susceptor temperature, precursor composition and residual oxygen concentration have been optimized. Crystallographic texture of the fabricated films was assessed by 2D-XRD. Composition of the REBCO films was determined using inductively coupled plasma mass spectrometry (ICP-MS) and optimum superconducting performance was observed near a composition of Ba/Cu = 0.72.