T$_C$SUH Special Seminar

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HSC 102
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MgB_2 Films for Superconducting RF (SRF) Cavities and Electronic Applications

ABSTRACT

Thin films of MgB_2 are of interest for applications in microwave electronics and for superconducting RF (SRF) cavities for particle accelerators. The high transition temperature of 40 K means that electronic devices can operate at approximately 20 K. Conventional SRF uses niobium cavities operating at 2 K. MgB_2 offers the potential of higher RF critical field and higher operating temperature than niobium and other conventional superconductors. Electronics applications require films on dielectric substrates and SRF requires films deposited on the inside of metallic three-dimensional structures. Due to the relatively long coherence length of 4 – 8 nm in MgB_2 the grain boundaries are not weak links and polycrystalline films exhibit excellent microwave properties.

In addition to the applications, MgB_2 is of interest because of the basic physics. It is unique in that it has two superconducting gaps, one of which has been determined to have unconventional symmetry. Using both stripline and dielectric resonators, we have measured the surface resistance and power handling of polycrystalline (nonepitaxial) MgB_2 films deposited by reactive evaporation on sapphire and bulk niobium substrates. Low surface resistance, 0.5 μΩ at 5 K and 2 GHz, comparable to niobium thin films at the same reduced temperature has been measured on both types of substrates. Measurements at high power handling show RF critical magnetic field >50 mT. We have successfully investigated several passivation techniques to prevent degradation due to environmental effects. The most successful uses *ex-situ* atomic layer deposition (ALD) of aluminum oxide. We have previously reported that the smaller of the two energy gaps in MgB_2 exhibits unconventional nodal six-fold ($\ell = 6$) symmetry. This was determined by our measurements of the temperature dependence of the intermodulation distortion at low temperatures. It has also been verified by observation of an anomalous temperature dependence of the penetration depth, which increases at low temperatures. This anomalous behavior is explained by Andreev bound states at the surface of the films that result from the nodal symmetry of the energy gap.

BIO

Daniel E. Oates received his B.A. degree in physics from Yale University and his Ph.D. degree in physics from the Massachusetts Institute of Technology. He held an Alexander von Humboldt fellowship at the University of Bonn, Federal Republic of Germany from 1971-72. In 1973-78 he was with Bell Laboratories, Holmdel, New Jersey. Since 1978, he has been at Lincoln Laboratory. His research at Lincoln Laboratory has included investigations of surface-acoustic-wave and bulk-acoustic-wave devices. Since 1988, his primary research interests have been in superconducting electronics, especially applications in frequency control and microwave-frequency analog signal processing. Motivated by the applications of superconductors, he has investigated the fundamental properties of both high-T_c and low-T_c superconductor materials at microwave frequencies and at high microwave power levels. The emphasis of the basic research in the HTS cuprate materials has been the study of the nonlinearities. More recently he has investigated MgB_2 for application in SRF accelerator cavities. The investigations include measurements of the microwave frequency properties to gain insight into the basic physics of this material. He has demonstrated that it is a promising material for applications in cavities and for electronic devices such as filters and delay lines.

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