Session 23aB

Synthesis, properties and possible applications of MgB_2 23aB1

Paul C. Canfield

Ames Laboratory and Department of Physics and Astronomy, Iowa State University, Ames, Iowa, 50011 U.S.A.

Over the past year there has been a great deal of excitement about the intermetallic superconductor MgB_2. MgB_2 has a superconducting transition temperature $T_c \sim 40$ K, can be synthesized as single phase powders, wire segments, and thin films with remarkably low normal state resistivity, and manifests a promising critical current density in the superconducting state. In this lecture I will review recent experimental work on MgB_2 and try to show how MgB_2 fits into the basic gestalt of superconducting, intermetallic compounds. This will include a review of such topics as: sample preparation, isotope effect, critical current and irreversibility field, and H_{c2} and its anisotropy. During the lecture I will try to indicate possible applications of this remarkable material.

de Haas-van Alphen effect in single crystal MgB_2 23aB2

A. Carrington[a], J.R. Cooper[b], N.E. Hussey[a], P.J. Meeson[a], E.A. Yelland[b], S. Lee[c], A. Yamamoto[c], S. Tajima[c]

[a]*H.H. Wills Physics Laboratory, University of Bristol, U.K.* [b]*IRC in Superconductivity, University of Cambridge, U.K.* [c]*Superconductivity Research Laboratory, ISTEC, Tokyo, Japan.*

We report observations of quantum oscillations in single crystals of the 39 K superconductor MgB_2. Three de Haas-van Alphen frequencies are clearly resolved. Comparison with band structure calculations strongly suggests that two of these come from a single warped Fermi surface tube along the c direction, and that the third arises from cylindrical sections of an in-plane honeycomb network. The measured values of the effective mass range from $0.44 - 0.68 m_e$. By comparing these with band masses calculated recently by three groups, we find that the electron-phonon coupling strength λ, is a factor ~ 3 larger for the c-axis tube orbits than for the in-plane network orbit, in accord with recent microscopic calculations.

23aB3 Experimental Study of Electron-phonon Coupling in MgB_2

Setsuko Tajima, Sergey Lee, Takahiko Masui, James Quilty, Ayako Yamamoto

Superconductivity Research Laboratory, ISTEC, Tokyo 135-0062, Japan

We have investigated various physical properties of MgB_2, using high quality single crystals. In the Raman scattering spectrum, the peak of E_{2g} boron vibrational mode shows anomalous broadening, softening and asymmetry, indicating strong coupling with the electronic system. From the temperature dependence of resitivity, it has been deduced that the high-frequency optical phonon makes a major contribution to the carrier scattering. The pressure dependence of resistivity and critical temperature reveals a big contribution of this phonon to the superconductivity. Combined with the result of de Haas van Alphen effect, these results demonstrate that the strong coupling of the boron E_{2g} mode with the boron σ-band gives rise to the high-T_c value of this superconductor. This work was supported by the NEDO, Japan.

23aB4 Scanning Tunneling Spectroscopy in MgB_2

Goran Karapetrov, Maria Iavarone, Alex E. Koshelev, W.K. Kwok, G.W. Crabtree, D.G. Hinks

Materials Science Division, Argonne National Laboratory, Argonne, IL 60439, USA

We present study of the anisotropic superconductor MgB_2 using a combination of scanning tunneling microscopy and spectroscopy. The results reveal two distinct energy gaps at Δ_1=2.3 meV and Δ_2=7.1 meV. Different spectral weights of the partial superconducting density of states are a reflection of different tunneling directions in this multi-band system. Our experimental observations are consistent with the existence of two-band superconductivity in the presence of interband superconducting pair interaction and quasiparticle scattering. Temperature evolution of the tunneling spectra follows the BCS scenario with both gaps vanishing at the bulk T_c. The data confirm the importance of Fermi-surface sheet dependent superconductivity in MgB_2 proposed in the multigap model by Liu et al.

23aB5 Parasitic Superconductivity in Magnesium Diboride

Morten R. Eskildsen[a], Martin Kugler[a], Shukichi Tanaka[a], Jan Jun[b], Serguei M. Kazakov[b], Janusz Karpinski[b], Øystein Fischer[a]

[a]*DPMC, University of Geneva, CH-1211 Geneve 4, Switzerland*
[b]*Solid State Physics Laboratory, ETH, CH-8093 Zurich, Switzerland*

We report results of scanning tunneling spectroscopy on a single crystal of MgB_2. The measurements were made on the surface of an as grown crystal, with the tunnel current parallel to the c-axis. In this geometry one only couples to the π-band, and we observe a single gap with $\Delta = 2.2$ meV. Vortex imaging was performed at a range of applied fields, $H \parallel c$, going from 0.05 T to 0.5 T, and revealed giant vortices with an extreme degree of vortex core overlap already at low fields. These results are consistent with superconductivity in the π-band being a *parasite* of the σ-band. Furthermore, using a single measured vortex profile, we are able to explain the anomalous field dependence of the elecronic specific heat.