Anisotropic Phase Diagram of Single-Crystal MgB_2

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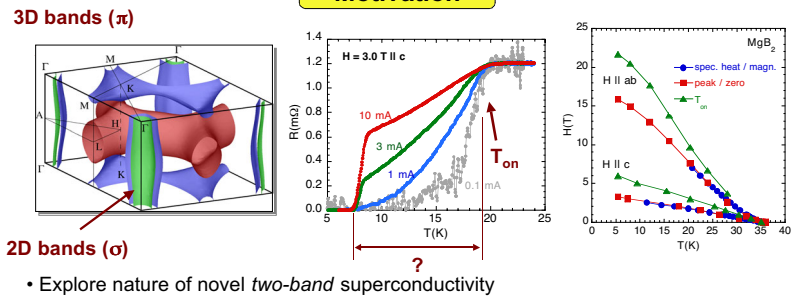
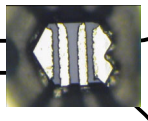
Motivation



- Explore nature of novel *two-band* superconductivity
- Good theoretical and experimental understanding of the phase diagram of MgB_2 will greatly benefit its promising use in applications.



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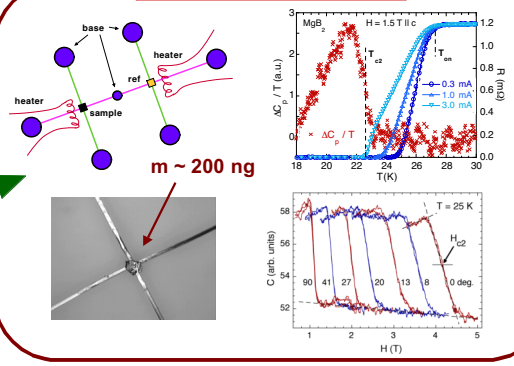
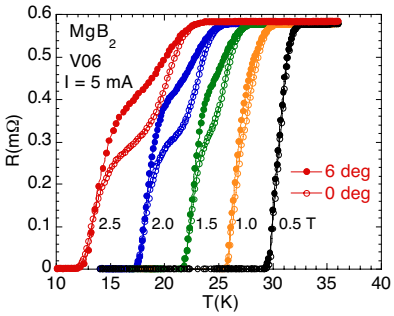
Tool: Nano-Calorimetry

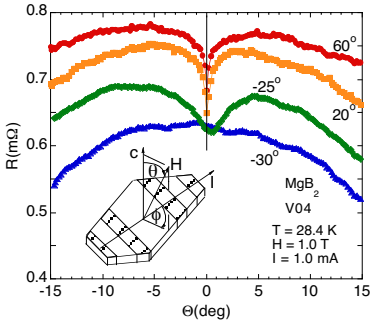


Results

Surface Superconductivity



Specific heat gives signature of H_{c2} at the onset of resistance. The response is strongly angular and current dependent above H_{c2}.

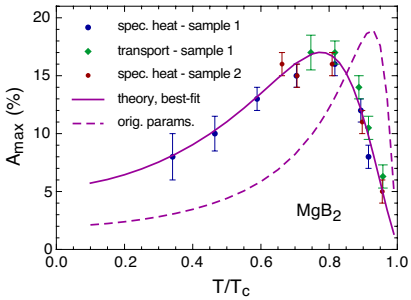


Indications of surface supercond.:

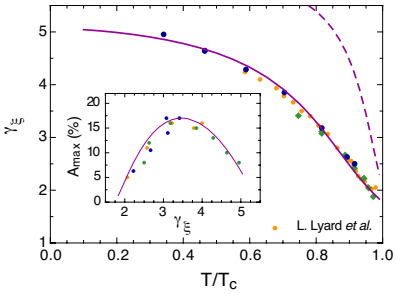
- Tilting across surfaces (**H||ab**, **H||c**)
- Sculptured surfaces (FIB)
- Non-Ohmic transport
- Specific heat

Two-Band Effects

Exotic properties from complex, multi-band (σ, π) Fermi surface.
Theory predicts interesting temperature and angular dependence of H_{c2}.

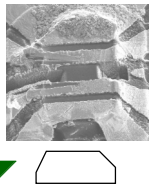


Deviations from Ginzburg-Landau
$A_{max} = \max\{1 - [H_{c2}(\theta)/H_{c2}^{GL}(\theta)]^2\}$

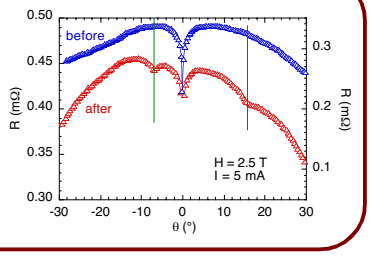


Strongly temperature-dependent H_{c2}-anisotropy γ_ξ

Tool: Focused Ion Beam



Cut cross section



Impact

- Surface superconductivity origin of novel features in MgB_2
- Good theoretical understanding and description of two-band effects
- Experimental indications of
  - Lower σ-band anisotropy (γ_σ = 5.4)
  - Isotropic π band
  - Increased interband coupling relative to band structure calculations

Future directions

- Enhance & Optimize H_{c2}
  - Thin films, doping
- Optimize J_c
  - Vortex pinning
- Study of disorder and doping effects on the two-band structure of MgB_2

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BES - DOE

Support was provided by the U. S. Department of Energy, Basic Energy Sciences, under contract W-31-109-ENG-38, and through the Fulbright program and the Sweden-America foundation (A.R.). Work with the FIB was carried out at the Center for Microanalysis and Materials, University of Illinois, which is partly funded by the U. S. DOE under grant DEFG02-91-ER45439.

MSD - ANL