Far-infrared optical conductivity of superconducting MgB2 films

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The discovery of superconductivity in MgB_2 by Akimitsu et al. has spawned intense research efforts - aimed both at applications and at understanding the nature of its high Tc. Here, we present first results of far-infrared transmission studies of thin MgB2 films in the vicinity of the superconducting gap 2D. Such measurements allow us to probe fundamental low-energy excitations such as the condensate and superconducting gap. Terahertz time-domain spectroscopy is employed in a broad spectral range up to 12 meV, directly providing the complex transmission function without the need for Kramers-Kronig transformations. Thin films of MgB_2 are grown on Al_2O_3 substrates by e-beam evaporation and subsequent ex-situ annealing in Mg vapor [1]. These films typically show T_c = 39 K and widths less than 1 K. In the presented measurements, performed at normal incidence and for T = 6 - 50 K, we observe dramatic changes in the optical response. Below Tc, a strong transmission decrease occurs for photon energies < 5 meV, whereas a marked increase takes place at higher photon energies. This behaviour mimics characteristic far-infrared spectral changes of metallic superconductors around their superconducting gap [2]. A preliminary analysis reveals that the real part of conductivity exhibits a strong depletion of oscillator strength resulting from the opening of the superconducting gap, while the imaginary part shows an inverse-frequency response due to the inductive response of condensed carriers.

[1] M. Paranthaman et al., Appl. Phys. Lett. (in press) (http://xxx.lanl.gov/cond-mat/0103569)
[2] L. H. Palmer, M. Tinkham, Phys. Rev. 165, 558 (1968).

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