Superconductivity-Induced Optical Anomaly in an Iron Arsenide

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One of the central tenets of conventional theories of superconductivity, including most models proposed for the recently discovered iron-pnictide superconductors, is the notion that only electronic excitations with energies comparable to the superconducting energy gap are affected by the transition. Here we report the results of a comprehensive spectroscopic ellipsometry study of a high-quality crystal of superconducting $Ba_{0.68}K_{0.32}Fe_2As_2$ that challenges this notion [1]. We observe a superconductivity-induced suppression of an absorption band at an energy of 2.5 eV, two orders of magnitude above the superconducting gap energy $2\Delta \sim 20$ meV. Based on density-functional calculations, this band can be assigned to transitions from As-p to Fe-d orbitals crossing the Fermi level. We identify a related effect at the spin-density-wave transition in parent compounds of the 122 family. This suggests that As-p states deep below the Fermi level contribute to the formation of the superconducting and spin-density-wave states in the iron arsenides.
All of the iron-pnictide superconductors are known to have multiple superconducting gaps. Redistribution of the occupation of the different bands below Tc could explain the optical anomaly we observed. It requires a lowering of the material‘s chemical potential in the superconducting state. In the presence of large Fe-As bond polarizability it can potentially enhance superconductivity in iron pnictides.
[1] A. Charnukha et al., Nature Communications, doi:10.1038/ncomms1223 (2011).