MAGNETO-OPTICAL STUDIES OF HIGH-T\textsubscript{c} SUPERCONDUCTORS

S.V. Dordevic (The University of Akron, Physics); A. Gozar, I. Bozovic, W. Si (Brookhaven National Laboratory, Material Science); C.C. Homes, G. D. Gu, (Brookhaven National Laboratory, Physics); Y.J. Wang (NHMFL)

Introduction

The mechanism of superconductivity in the cuprates continues to evade resolution. In particular, the origin of a bosonic mode responsible for pairing is currently at the center of condensed matter research. Lee et al. have recently suggested magneto-optical measurements as a new way to test the nature of this mode [1,2]. Namely, it has been known from neutron scattering measurements that magnetic modes in cuprates are sensitive to the application of magnetic field. If charge carriers are indeed coupled to them, then the application of magnetic field should also affect charge dynamics. However, the results of Lee et al. on two underdoped YBCO samples in magnetic fields up to 7 Tesla did not reveal any field induced changes in the reflectance [1,2]. In this work we have extend the magneto-optical measurements to several other cuprate families and magnetic fields up to 33 Tesla. Similarly to Lee's original work, our measurements have revealed extreme insensitivity of optical constants of cuprates to external magnetic field.

Experimental

We have performed extensive magneto-optical measurements on several families of high-T\textsubscript{c} cuprates [3], including optimally doped YBa\textsubscript{2}Cu\textsubscript{3}O\textsubscript{7-}\textdelta (YBCO) 1.6 \textmu m thick film with T\textsubscript{c} = 92 K, several Bi\textsubscript{2}Sr\textsubscript{2}CaCu\textsubscript{2}O\textsubscript{8+}\textdelta (Bi2212) samples with different doping levels and T\textsubscript{c}'s, underdoped La\textsubscript{1.875}Ba\textsubscript{0.125}CuO\textsubscript{4} with T\textsubscript{c} = 2.4 K and optimally-doped Nd\textsubscript{1.85}Ce\textsubscript{0.15}CuO\textsubscript{4} (NCCO) with T\textsubscript{c} = 23 K. For all samples field induced changes of reflectance R(\omega, H)/R(\omega, 0 T) have been measured under the zero-field cooling conditions at T = 4.2 K, using the 18 Tesla superconducting magnet at the National High Magnetic Field Laboratory. Magnetic field was applied perpendicular to CuO\textsubscript{2} planes and changes in the in-plane reflectance were monitored in the frequency range between approximately 350 and 2300 cm\textsuperscript{-1} (43 – 285 meV).

In addition, we have used 33 Tesla resistive magnet to measure magneto-transmission properties on an optimally doped La\textsubscript{1.85}Sr\textsubscript{0.15}CuO\textsubscript{4} (LSCO) film with T\textsubscript{c} = 41 K. The film was grown on LaSrAlO\textsubscript{4} (LSAO) substrate using MBE and had the thickness of 78 nm. To avoid the multiple reflections in the substrate, the substrate was polished to approximately 10\textdegree. The advantage of this magneto-transmission set up is that the temperature of the sample can also be varied between 5 and 45 K.

Results and Discussion

Within the error bars of experiments, we did not detect any field induced changes of reflectance in any of the studied samples. Note that LBCO sample had T\textsubscript{c} = 2.4 K and was therefore in the normal state at the measurement temperature (4.2 K). On the other hand, NCCO samples have B\textsubscript{c2} ~ 7 T, and 18 T was therefore sufficient to completely destroy superconductivity. However in neither case did we observe any field induced changes. Several Bi2212 samples with different doping levels (both underdoped and overdoped) were also measured and in none of them were any field-induced effects detected. Similarly, in optimally doped LSCO film at the lowest temperatures there are no field-induced changes [4].

Conclusions

In conclusion, our magneto-optical measurements on several cuprate samples have revealed that, within the error bars of experiments, there are no field-induced changes in the optical properties. These results indicate that charge carriers in the cuprates might not be coupled to magnetic modes as strongly as originally thought.

References