We study the interaction of a high frequency AC current with a magnetic field in an YBCO thin film by using time resolved magneto-optical imaging. Since MO imaging is the only technique that offers combined high spatial and temporal resolution, it is the most suitable technique for accurate dynamic studies of flux distributions. We find that the total current distribution can be described as the superposition of a quasi-steady state shielding current, which is different from the shielding current induced by only an applied magnetic field, and a time varying transport current that does not induce any flux inside the thin film. Our results can be used as a benchmark for future theoretical modeling.

Ultra-Short Laser Pulse Beam Shaping

We study the spatial average intensity profile of an ultrashort laser pulse passing through a laser beam shaping system, which uses diffractive optical elements to reshape the Gaussian beam profile into a flat-top distribution. We developed a theoretical model simulating the pulse beam shaping; comparison of the theoretical calculation and experimental data indicates that this system works well for ultrashort pulses (> 100 fs). We also studied the effects of lateral misalignment, beam size deviation and defocusing on the beam intensity profile.

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Research

We are interested in the physics and development of novel electronic and magnetic devices, as well as exploring fundamental optical interactions between light and matter. Our research covers a wide range of areas with an emphasis on novel semiconductors, magnetic heterostructures, colossal magnetoresistance materials, and high-TC superconductors. The focus of our research is on dynamical processes (electronic, magnetic, and vibrational) localized at surfaces, interfaces, as well as at defects and impurities in the bulk. Most of our research involves nonlinear optical techniques implementing ultrafast high-power lasers with femtosecond time resolution; this allows the characterization of buried interfaces not easily accessible by conventional surface probes.

Vibrational Dynamics of Defects in Semiconductors

The goal of this project is to elucidate the dynamics of local vibrational modes (LVMs) of defects related to light impurities in crystalline semiconductors, including Si, Ge, GaAs, and ZnO. Knowledge of the rates and pathways of vibrational energy flow is critical for understanding thermally and electronically stimulated defect and impurity reactions and migration in semiconductors. Hence a detailed understanding of the energy transfer channels and the coupling mechanism between LVMs and the phonon bath of the host material is needed. The mechanisms for population and phase relaxation upon excitation of those modes, in both frequency and time domain, are investigated.

Magnetic Heterostructures

The use of carrier spin as a new degree-of-freedom portends new functionality and enhanced performance in semiconductor devices. The efficient electrical injection of spin-polarized carriers into semiconductor heterostructures is an essential requirement to implement semiconductor spintronic devices. Significant progress has been made using magnetic semiconductor and ferromagnetic metals as spin injection contacts, however, effects of interface structure, and electronic and magnetic interface properties on spin injection across heterostructure interfaces are less understood. Consequently, characterization of the band-offsets, magnetic anisotropy switching, and spin dynamics at the heterointerface are required to optimize the spin injection efficiency.

Colossal Magnetoenceptitive Perovskite Manganese Oxides

Several physical properties -- charge, spin, lattice, and/or orbital coupling -- are strongly correlated in transition metal oxides (TMOs) and other materials. This phenomenon leads to interesting effects, such as colossal magnetoresistance (CMR), where small changes of magnetic field generate enormous variations in resistance, and high temperature superconductivity.

Our research is focused on the excitation and characterization of spin dynamics, magnetization switching, electron-lattice coupling, and lattice vibration through time resolved magneto-optic Kerr effect (TR-MOKE), time-resolved magnetization-induced second-harmonic-generation (TR-MSHG), two-color pump-probe reflectivity spectroscopy, and different frequency mixing. These experiments explore the ultrafast response of interfacial magnetism, which is strongly correlated to electronic structure and phase complexity, and important in high-speed spintronic applications.

Magneto-Optical Imaging of Superconductors

Type-II and high-temperature superconductors (HTS) subjected to quasi-static changes of both applied magnetic fields and transport current have long been studied using different experimental methods. Hall sensor array, scanning Hall probe and magneto optical imaging measurements of HTS thin films have revealed interesting features as the hysteretic flux penetration and inhomogeneities or disordered vortex states when applying an alternating magnetic field or transport current to the sample. The origin of the hysteretic magnetic field and electrical current distributions is generally understood in terms of critical-state theory, which describes the behavior of HTS thin strips in quasi-static changes of an applied magnetic field or a transport current.