Structure and Dynamics of Internal Interfaces

Ulrich Höfer
Department of Physics, Philipps-Universität Marburg, Germany

Buried internal interfaces between two solids play an increasingly important role in modern materials science. The microscopic understanding of chemical bonding, electronic structure and energy transfer processes at such interfaces, however, is lagging behind that of volume or surface properties. In a new Collaborative Research Centre that aims to close this knowledge gap, scientists in Marburg working in the fields of chemical synthesis, semiconductor physics, structural analysis and laser spectroscopy will develop and investigate model systems of different classes of hetero-interfaces.

In this talk, I will briefly introduce the SFB 1083 and discuss preliminary work of my own group. In the first example, I will show that a characteristic phonon mode exists at the lattice-matched polar/nonpolar semiconductor interface GaP/Si. In the second example, I will address the dynamical properties of interfacial electronic states between metals and organic semiconductors.

ZnO as a Tuneable Metal: New Types of Surface Plasmon Polaritons for Coupling with Molecular Excitations

Fritz Henneberger
Department of Physics, Humboldt-University Berlin, Germany

The interaction of metals with electromagnetic radiation gives rise to collective charge excitations called surface plasmon polaritons. The potential of these coupled light-matter states for creating nano-scale photon-based circuits is the core of what is summarized today by the term "plasmonics". However, when targeting the infrared spectral range, traditional metals like gold and silver suffer from strong losses and damage of the surface localization. In this talk, I demonstrate that heavily doped semiconductors represent an excellent alternative opening even new perspectives.

Doping of ZnO by Ga allows for generation of free electrons up to concentrations of about 10^{21} cm^{-3} without significant deterioration of the crystal structure. In this way, a metallic dielectric function emerges with a negative real part tuneable from the mid infrared up to telecommunication wavelengths. The losses are at least one order of magnitude lower than for Au or Ag. Using epitaxial multi-layer structures of different doping level, new types surface plasmon polaritons with dispersion relations that can be engineered in a unique way are formed. In contrast to the standard dielectric/metal excitations, the surface-plasmon-polariton frequency approaches a finite value in the zero-wavevector limit at metal/metal-type interfaces. Moreover, the group velocity can be almost arbitrarily shaped for achieving, e.g., phase matching for nonlinear processes or even anomalous dispersion. I also report on resonant coupling with distinct interference features of these surface plasmon polariton states to molecular vibrations. Moreover, hybridization of cavity photons and surface plasmon polaritons is observed defining novel routes for achieving and controlling stimulation phenomena in plasmonic systems.