Abstract

In this thesis I report on the investigation of lanthanide-metal surfaces by scanning tunneling microscopy (STM) and spectroscopy (STS) at temperatures between 10 and 100 Kelvin. STS combines the advantages to probe the occupied as well as the unoccupied electronic density of states with high energy and lateral resolution.

For the first time, we found quantum-well states in ultrathin films of Yb(111)/W(110). We determined the bulk-band dispersion in Γ-L direction and analyzed the electron dynamics within this band.

For the trivalent lanthanide metals, we investigated the exchange splitting of the (0001) surface states as a function of $4f$-spin moment, temperature, and film thickness. The observed small deviation from the previously reported linear $4f$-spin dependence is explained by the lanthanide contraction. The temperature and thickness dependencies show that the surface states – due to their relatively high degree of localization – are not solely sensitive to long-range magnetic order, but are also strongly influenced by the short-range magnetic order.

Thorough analysis of the lifetime broadening of the surface states provides information about different scattering mechanisms that determine the electron dynamics: electron-electron, electron-phonon, and electron-magnon scattering. The relatively short lifetimes for the spin-polarized unoccupied surface states is most likely due to strong electron-magnon scattering. The electron-phonon coupling can be derived from temperature-dependent measurements. The influence of defect scattering was studied specifically at single adsorbates. Thereby, an adsorbate-induced state was found at the surface of Dy(0001) which seems to exhibit some kind of „switching" behavior.

Scanning tunneling spectra from the trivalent lanthanide metals exhibit unexpected features directly at the Fermi energy. These features are presumably caused by many-body effects due to the interaction of the localized surface states with conduction electrons.

In the vicinity of single magnetic defect atoms (Ho and Gd) that are embedded within the surface layer of Lu(0001), we found a novel spectroscopic signal. We interpret this feature as the signature of a Kondo resonance. The Kondo effect is unexpected in these systems. The results indicate that it only appears at the surface. The lateral extent of the resonance can be explained by the size of the Kondo screening cloud.