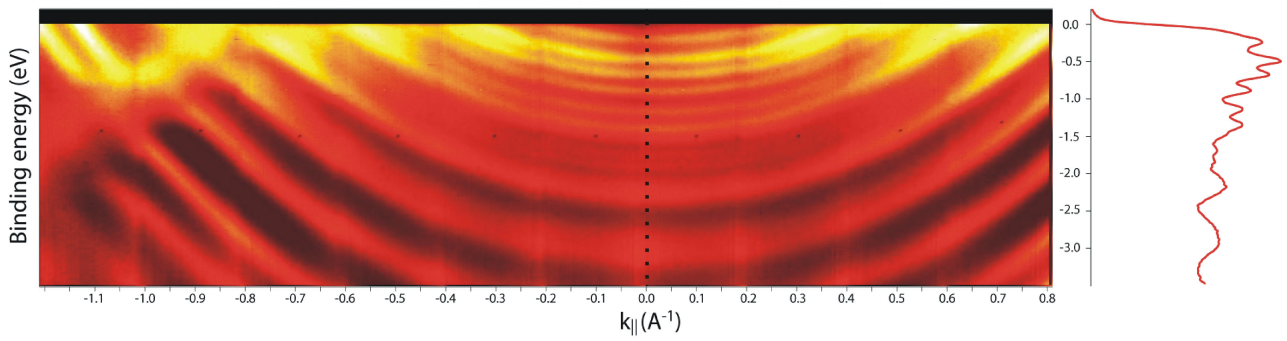
Quantum Size Effects in uncoupled Al layers on graphitized SiC

Application Notes

The ongoing trend of miniaturization of electronic components is resulting in associated technological advances in various fields of research and industry, and in particular, this has been playing an important role for Electron confinement in potential wells. A thin metal film can serve as such a potential well. In the direction normal to the metal surface, the electron is trapped between the vacuum on the one side and and between the substrate on the other side. These films serve as „model systems" to gain more understanding of numerous phenomena in solid state physics.

By means of Photoelectron spectroscopy, one can track the electronic structure (Quantum well states) and exactly measure the two-dimensional band structure as a function of the parallel component of the Wave vector $k_{||}$. In the figure below one can see the angular resolved photo-emission intensity as a function of the binding energy and $k_{||}$. The parabolic lines originate from an Aluminum layer on single-crystal graphite, which can be produced with high structural quality on a SiC(0001)-surface.

In the center of graphite's (2D) Brillouin Zone, there are no substrate bands up to a binding energy of 4eV below the Fermi energy, so that one can investigate the electronic states of the Al-layer without interference from the substrate. So far, such data has frequently been acquired as spectra with a single-channel spectrometer. By using a 2D Spectrometer, a very high angular resolution is possible, allowing one to plot and measure the electronic structure over a large area (see figure). The adoption of 2D-Electron Spectrometers has revolutionized the field of "Valence band photo emission" research.



The Photoemission intensity distribution as a function of the binding energy and the parallel component of the wave vector from a nominal nine monolayers thick Al-coating on a single-crystal Graphite layer on SiC(0001). The measurements were carried out with a photon energy of 15 eV at BESSY in Berlin and a SPECS PHOIBOS 100 2D-CCD Analyzer.
Data courtesy J.H. Dil, Th. Kampen, K. Horn (Fritz Haber Institute, Berlin)

Projecting the 2D map shown in the last figure into 1D leads to the commonly known line spectra (see right side of the figure). From this image, it is more clearly seen that the lines are irregularly spaced due to a mixture of differing island heights. Nevertheless they are clearly separated from one another, which is indicative of a preference for specific island heights. This phenomenon (electronic growth) has already been repeatedly observed. It is due to the fact that the energy minimization prefers to form those layer thicknesses in some of the uppermost quantum levels, that are furthest away from the Fermi energy. Other important aspects of quantum-well level research pertain to the absolute determination of band structures, characterization of electron-phonon coupling, the mechanics of coupling in magnetic layer structures, and much more.

References:

[1] T.C. Chiang, Surf. Sci Rep. 39 (2000) 181.
[2] I. Forbeaux, J.-M. Themlin, J.-M. Debever, Phys. Rev. B 58 (1998) 16396.
[3] T. Seyller et al, Surf. Sci., in press. The support from Dr. Seyller in the preparation of the single-crystal graphite is highly appreciated.
[4] See J.H. Dil et al, Phys. Rev. B 70 (2004) 045405 and references therein.

Mode	D	Acceptance Angle	Energy Range
High Angular Dispersion	3.2 mm/°	± 3°	Ep × [1 – 4]
Medium Angular Dispersion	2.2 mm/°	± 4°	Ep × [1 – 200]
Low Angular Dispersion	1.2 mm/°	± 7°	Ep × [0.05 – 30]
Wide Angle Mode	0.5 mm/°	± 13°	Ep × [0.1 – 3]

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