O 8: Methods: Scanning Probe Techniques I

Time: Monday 11:15–12:45 Location: H41

O 8.1 Mon 11:15 H41

Tip-Sample Distance-Dependant Tunneling Spectroscopy of Ultra-Thin Layer of d8 Metal-Phthalocyanines — •Thiruvancheril Gopakumar, Jan Meiss, and Michael Hietschold — Chemnitz University of Technology, Institute of Physics, Solid Surfaces Analysis Group, D-09107 Chemnitz, Germany.

Tip-sample distance-dependant tunneling spectroscopy (TD-TS) on the thin layers of naphthalocyanine and tin-naphthalocyanine show a strong tip-sample distance-dependant HOMO-LUMO gap shrinking, which was assigned to the electronic nature of molecule-substrate interface.[a] For the clear understanding of this scenario and the factors which influence the HOMO-LUMO gap shrinking we have extended the TD-TS to ultra-thin film of d8 metal-phthalocyanine on HOPG (0001). A similar HOMO-LUMO gap shrinking is observed and the rate of change in HOMO-LUMO gap with respect to the distance is found to be decreasing/dependant on the molecular electronic nature, which is further understood in terms of molecular polarisabilty. Theoretical calculations were performed to correlate the molecular polarisability and the electronic nature (electron density) of frontier orbitals.

[a]. T. G. Gopakumar, F. Muller, M. Hietschold, J. Phys. Chem. B. 2006, 110(12), 6060-6065.

O 8.2 Mon 11:30 H41

Dispersion relation of field emission states — •Michael Fechner, Christian Heiliger, Peter Zahn, Ingrid Mertig, Stephan Grosser, Christian Hagendorf, and Wolf Widdra — Martin-Luther-Universität, Institut f. Physik D06099 Halle,Germany

Scanning tunneling microscopy (STM) and scanning tunneling spectroscopy (STS) have been applied to investigate field emission states on Ag(001) surfaces. The STS measurements have been performed in constant current mode where the distance z(V) between tip and sample as a function of the applied voltage is controlled by the tunneling current. Field emission states cause strong changes in z(V) which indicates their energetic position [1]. Combining STM and STS the dispersion relation of the field emission states have been measured as has been demonstrated earlier on Cu(001) [2]. The previous study on Cu(001) found a free electron dispersion with an effective electron mass smaller than the free electron mass. For Ag(001) we observe a free electron like dispersion with the band bottom shifted with respect to the energy of the field emission state. A theoretical model based on the finite-difference method has been developed to reproduce the z(V) characteristics and to simulate the combination of STS and STM experiments to obtain the dispersion relation. Our results emphasize that the effective mass found in previous studies is an artifact of the operation modus whereas the band offset is the consequence of the energy uncertainty of the field emission state.

[1] G. Binnig et al., Phys. Rev. Lett. 55, 991 (1985).
[2] P. Wahl et al., Phys. Rev. Lett. 91, 106802 (2003).

O 8.3 Mon 11:45 H41

Identification of vibrations in video-speed SPM scanners — •G.J.C. van Baarle[1,2], P. Schakel[1], L. Crama[1], T.H. Oosterkamp[1], J.W.M. Frenken[1], and M.J. Rost[1,2] — [1]Kamerlingh Onnes Laboratory, Leiden University, P.O. box 9504, 2300 RA Leiden, The Netherlands — [2]Leiden Probe Microscopy, P.O. box 9504, 2300 RA Leiden, The Netherlands

For a wide variety of surface and interface phenomena in both fundamental and applied contexts, it is becoming increasingly important to visualize them with atomic or molecular resolution combined with high speeds.

In order to avoid crashes while scanning rough surfaces at high speeds, one has to be able to perform high speed feedback on the probe position. We will demonstrate that the excitation of vibrations in the microscope sets a limit to the resolution as well as the speed of the measurement. We will present a very sensitive method to measure the vibrations in an STM.

From the experimental data obtained with this method we can clearly identify the origin of vibrations. We will show that the obtained information can be used to tune the PI-regulator settings optimally, without having any 'a priori' knowledge of the closed loop transfer function of the entire system.

O 8.4 Mon 12:00 H41

A challenge in STM-technology: video-rate imaging during film growth — •Vincent Fokkema, Mark den Heijer, Arjen C. Geluk, and Marcel J. Rost — Kamerlingh Onnes Laboratory, Leiden University, P.O.Box 9504, 2300 RA Leiden, The Netherlands

We developed a scanning tunneling microscope (STM) that will be, for the first time, capable of monitoring film growth *during* the deposition of films with significant thicknesses. To capture the dynamics involved in film growth, both high spatial and temporal resolution are required. The wish to image a growing surface during physical vapor deposition (PVD) or during ion bombardment demands an open structure of the microscope, which contradicts the desired stability for high speed imaging. Bearing this in mind, we optimized the rigidity of the scanner to not be hampered by mechanical resonances, which would render the system incontrollable. To this end we modeled the complete STM with finite elements analysis (FEA), of which the results were compared with actual measurements. Finally we received new insights regarding the design rules for the ultimate STM.

O 8.5 Mon 12:15 H41

Quantitative probing of the thermal nearfield radiation on the nanometerscale — •Uli Wischnath, Joachim Welker, Andreas Knübel, and Achim Kittel — Energie- und Halbleiterforschung, Uni Oldenburg, Germany

Recent publications report experiments in the field of evanescent thermal radiation on the nanometer scale and the according theory. A description based on macroscopic stochastic Maxwell theory does not seem to hold on this length scales. We have developed an experimental tool to investigate this type of radiation. Our experimental setup consists of a Scanning Thermal Microscope based on a STM with a modified scanner and a thermocouple sensor. We measure tunneling current and temperature of the tip simultaneously and are able to retract the thermocouple sensor by a well defined distance from the surface. Thus we are able to take precise heat flux versus distance curves which are qualified to test the predictions made by the different theories. We have shown that the rise of the heat flux between a probe at room temperature and a cooled sample is far less steep for small distances than predicted from stochastic Maxwell theory. The predicted inverse power law behavior for the heat flux due to the contributions of evanescent modes can only be observed for distances ranging from about 50 nm to about 10 nm. For smaller distances deviations become evident which can be associated to correlations in the fluctuations of the electromagnetic radiation at length scales in the nanometer range[1]. This seems to be a fingerprint of the breakdown of a macroscopic theory.

[1] Kittel et al. (2005), Phys. Rev. Lett. 95, 224301 (2005)

O 8.6 Mon 12:30 H41

Eine neue Methode zur Berechnung von Zustandsdichten aus gemessenen Tunnelspektren — •Berndt Koslowski, Christof Dietrich, Anna Tschetschetkin und Paul Ziemann — Institut für Festkörperphysik, Universität Ulm, 89069 Ulm

Vorgestellt wird eine neue Methode zur Berechnung von elektronischen Zustandsdichten (DOS) aus I-V-Spektren, die mit dem Raster-Tunnel-Mikroskop gemessenen wurden. Ausgangspunkt ist die WKB-Näherung für 1-dimensionales Tunneln. Durch einfache Näherung lässt sich ein Ausdruck für die DOS ableiten, der im Gegensatz zu früheren Methoden nicht nur dI/dV, sondern neben bestimmbaren Parametern (Abstand, Austrittsarbeit) auch den Tunnelstrom I selbst enthält. Hiermit wird eine auf die Oberfläche zurückgerechnete DOS bestimmt. Ferner kann die DOS der Probe durch eine Volterra-Gleichung 2. Art ausgedrückt werden, so dass sich das Neumann*sche Näherungsverfahren anwenden lässt. Vergleich mit gerechneten Modellzustandsdichten zeigt, dass dieses Iterationsverfahren sehr schnell konvergiert und man bereits nach etwa drei Iterationsschritten die Modell-DOS aus dI/dV erhält. Analog lässt sich auch für die DOS der Tunnelspitze eine Volterra-Gleichung formulieren, so dass ein System von Integrodifferentialgleichungen entsteht. Falls sich zusätzliche experimentelle Informationen gewinnen lassen, z.B. die differentielle Barrierenhöhe d2I/(dVdz), so kann das Gleichungssystem selbstkonsistent gelöst werden. Damit erreicht man im Idealfall eine Entfaltung der beiden DOS von Probe und Spitze.