DS 9: Optical Analysis of Thin Films

Time: Monday 15:00–16:15 Location: CHE 91

DS 9.1 Mon 15:00 CHE 91

Optical constants of nickel and gold from 0.06 to 6.0 eV at 300 K — •Stefan Zollner and Farzin Abadizaman — New Mexico State University, Las Cruces, NM, USA

Using spectroscopic ellipsometry, we performed high-precision measurements of the optical constants of gold and nickel thin films at room temperature from the mid-infrared to the near-ultraviolet spectral region. Gold shows typical Drude behavior in the infrared with a single species of charge carriers and several optical interband transitions with an onset of 2.54 eV. However, deviations from a simple Drude model are noticed at the longest wavelengths, possibly due to diffraction or the anomalous skin effect. For nickel, measurements were performed in UHV after preparing a clean surface by annealing in vacuum. The optical constants of Ni require a description with two species of Drude charge carriers with vastly different damping constants, and several interband transitions. The energies of the interband transitions can be determined by subtracting the Drude response from the optical constants. Several different representations of the optical constants of Ni and Au will be discussed, including a frequency dependent scattering rate and a renormalized effective mass. Tabulated optical constants as well as model line shapes fitted to the data will be presented.

DS 9.2 Mon 15:15 CHE 91

Validation of Optical Constants in the EUV Spectral Range — •Qais Saadeh[1], Victor Soltwisch[1], Frank Scholtze[1], and Philipp Naujok[2] — [1]Physikalisch-Technische Bundesanstalt (PTB), Abbestraße 2-12, 10587 Berlin, Germany — [2]OptiX fab GmbH, Hans-Knöll-Str. 6, 07745 Jena, Germany

After the introduction to high volume manufacturing, continuous development of EUVL systems and components will require the use of advanced materials, for example as absorber layers on next generation photomasks. In the EUV or soft X-ray spectral range the optical parameters of many materials are often not well known or based on theoretical calculations and interpolations. Thus, highly accurate measurements of the optical constants of thin layers obtained from different material compositions are necessary for the realistic modelling of new photomasks designs. Reflectometry is a widely used method for the determination of film thickness, especially in the X-ray spectral range. The same approach can also be used in EUV with a different focus. The aim is then to reconstruct the optical material parameters, the real and imaginary part of the refractive index, from the reflectivity measurements with a well-defined layer thickness. In this study, we will present the feasibility of determining the optical constants for candidate materials for EUV photomask absorbers using EUV reflectometry.

DS 9.3 Mon 15:30 CHE 91

Grazing incidence X-ray fluorescence measurement on nanostructures for element sensitive reconstruction — •Anna Andrle[1], Philipp Hönicke[1], Philipp-Immanuel Schneider[1], Yves Kayser[1], Martin Hammerschmidt[2], Sven Burger[2,3], Frank Scholze[1], Burkhard Beckhoff[1], and Victor Soltwisch[1] — [1]Physikalisch-Technische Bundesanstalt, Abbestrasse 2-12, 10587 Berlin, Germany — [2]JCMwave GmbH, Bolivarallee 22, 14050 Berlin, Germany — [3]Zuse Institute Berlin, Takustrasse 7, 14195 Berlin, Germany

The production of the current and next generation of semiconductor devices requires a reliable and non-destructive characterization of the material composition and dimensional parameters of the nanostructures is necessary. A method based on grazing incidence X-ray fluorescence measurements is applied to lamellar gratings made of Si_3N_4. This technique is based on the X-ray standing wave field, which is sensitive to both the elemental composition and dimensional parameters of the nanostructures. With a finite element Maxwell solver, the X-ray standing wave field can be calculated and used in conjunction with a parameterized nanostructure to model experimental data and thus, derive the spatial distribution of elements and the geometric shape with subnm resolution. This reconstruction is executed with a Bayesian optimization approach to minimize the computational effort.

DS 9.4 Mon 15:45 CHE 91

Ultrafast time-resolved spectroscopic ellipsometry user station at ELI-Beamlines — •Martin Zahradník — ELI Beamlines. Institute of Physics. Czech Academy of Science. Za Radnicí 835, 252 41 Dolní Břežany. Czech Republic

Time-resolved ellipsometry is based on a pump-probe approach. The pump pulse from a laser hits the sample first, triggering charge transfer processes that change the dielectric function. The sample response, the change in the dielectric function, is then measured by a probe pulse. By varying the time delay between the pump and the probe pulses (from few femtoseconds to nanoseconds), the complete picture of the ultrafast phenomenon is obtained.

Our time-resolved PSC(R)A ellipsometer at ELI Beamlines has a super continuum probe beam that covers from 350-750 nm generated on a CaF_2 crystal by 1 KHz, 7 mJ, 35 fs, Ti-sapphire laser. Thanks to an optical parametrical amplifier, the pump beam could be any wavelength from 190 to 2000 nm. A new call will be open for users to carry on measurements at this ellipsometer. During the talk, the details of the setup will be explained and example data showing the dynamics of the dielectric function of model thin films will be presented.

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DS 9.5 Mon 16:00 CHE 91

Excitonic Wave Function Reconstruction from Near-Field Spectra Using Machine Learning Techniques — Fulu Zheng and •Alexander Eisfeld — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Strasse 38, D-01187 Dresden, Germany

A general problem in quantum mechanics is the reconstruction of eigenstate wave functions from measured data. Self-assembled molecular aggregates on dielectric surfaces are promising candidates for optoelectronic devices. Strong interactions between the transition dipoles of the molecules lead to delocalized excitonic eigenstates where an electronic excitation is coherently shared by many molecules [1]. Information about these states is vitally important to understand their optical and transport properties. Here we show that from spatially resolved near field spectra it is possible to reconstruct the underlying delocalized aggregate eigenfunctions [2, 3]. Although this high-dimensional nonlinear problem defies standard numerical or analytical approaches, we have found that it can be solved using a convolutional neural network. For both one-dimensional and two-dimensional aggregates we find that the reconstruction is robust to various types of disorder and noise.

[1] A. Eisfeld, C. Marquardt, A. Paulheim, and M. Sokolowski, Phys. Rev. Lett. 119, 097402 (2017). [2] X. Gao and A. Eisfeld, J. Phys. Chem. Lett. 9, 6003 (2018). [3] F. Zheng, X. Gao and A. Eisfeld, Phys. Rev. Lett. 123, 163202 (2019).