SCIENTIFIC HIGHLIGHT

X-ray "movie" provides insights into the formation of molecular layers

Thin-film technologies that promise control on the atomic and molecular scale have attracted increasing interest in recent years as traditional manufacturing processes reach their fundamental limits. A team from the Department of Physics at the Humboldt-Universität zu Berlin, led by Anton Zykov, Stefan Kowarik and Jürgen P. Rabe (member of IRIS Adlershof) in collaboration with colleagues from the PETRA III Synchrotron at DESY Hamburg has now studied the non-equilibrium growth of molecular layers using innovative, time-resolved X-ray scattering. The movie sequence of the X-ray scattering during the molecular beam deposition was chosen as the cover image of a special topic issue of the Journal of Chemical Physics on "Atomic and molecular layer processing".

Semiconducting organic molecules have significant potential for future applications such as organic light-emitting diodes (OLED), camera sensors or memory devices. Many of these components are based on ultrathin layers of functional molecular materials. Their preparation by deposition of molecules from the gas phase is a complex process involving molecular adsorption on a substrate, molecular diffusion and self-assembly. Since many of these processes do not proceed under conditions of local thermodynamic equilibrium, these processes and their velocities are still not well understood.

By means of innovative X-ray measurements of diffuse scattering at the P03 Beamline of the PETRA III synchrotron, the researchers were able to record "movies" of the growth processes on the nanoscale. The measurement makes it possible to follow the nucleation, island growth and the roughness evolution of the layer.

The researchers show that the results of the new X-ray technique are consistent with established scanning probe techniques and time-resolved measurements are possible without disturbing the growth.

In the study, a significant improvement in the diffusivity of molecules between the first and the subsequent molecular layers was found and the nucleation energy was determined within the framework of recent growth theories. The application of the new X-ray scattering technique will help to take our understanding beyond a recipe-based perspective to that of sound fundamental understanding of molecular growth.

Diffusion and nucleation in multilayer growth of PTCDI-C8 studied with in situ X-ray growth oscillations and real-time small angle X-ray scattering

A. Zykov, S. Bommel, C. Wolf, L. Pithan, C. Weber, P. Beyer, G. Santoro, J.P. Rabe, and S.Kowarik

J. Chem. Phys. 146, 052803 (2017)
DOI: 10.1063/1.4961460