Growth and structure of phthalocyanine thin films on SiO_2 and functionalized SiO_2 by self assembling monolayers

D. G. de Oteyza[1], E. Barrena[1], J. O. Ossó [2] and H. Dosch[1,3]
[1] Max Planck Institut fuer Metallforschung, Heisenbergstr. 3, 70569 Stuttgart
[2] Institut de Ciència de Materials de Barcelona, CSIC, 08190 Bellaterra
[3] Institut fuer Theoretische und Angewandte Physik, Universitaet Stuttgart, 70550 Stuttgart
dgoteyza@mf.mpg.de

Thin films of planar aromatic molecules are receiving great attention due to the new applications they offer as well as for the promise of low cost electronics. Copper hexadecafluorophthalocyanine ($F_{16}CuPc$) is one of the few air stable organic n-type semiconductors and therefore an interesting candidate for organic electronic devices.
A key element for the controlled growth of organic thin films is the substrate, since the resulting structure depends on the delicate balance between the substrate-molecule and the intermolecular interaction. The functionalization of the surfaces by self assembling monolayers (SAMs) allows tailoring the surface properties while preserving the morphology. We have used AFM and X-ray diffraction techniques to study the growth and structure of $F_{16}CuPc$ on SiO_2 and on functionalized SiO_2 by octadecyltriethoxisilanes (OTE). OTE is a methyl terminated SAM with a lower surface energy than SiO_2. The study has been performed for different $F_{16}CuPc$ film thicknesses.
$F_{16}CuPc$ films grown on SiO_2 are smooth and show good out of plane order with very low mosaicity (0.015º). Their (001) plane is oriented parallel to the surface, with the molecules essentially upright. Films grown on OTE show island growth that gives rise to large elongated crystallites up to the size of microns. The molecular order on each crystallite has been resolved by AFM, showing columns that are always parallel to the long axis of the crystallites. In spite of the morphological differences, the films on OTE exhibit the same out-of-plane lattice parameter and low mosaicity as on SiO_2. Gracing Incidence X-ray Diffraction (GIXD) measurements indicate that the crystallites on both surfaces are randomly oriented in the film plane, as expected for the isotropic substrate's surfaces. The domain size obtained by GIXD is larger for the films on OTE compared to those on SiO_2. These results are in agreement with the AFM images. The mean lateral domain sizes for the films on OTE are larger than the mean domain sizes of the OTE monolayer itself. This indicates that the molecule-substrate interaction is weak enough not to limit the lateral order of the film.

Related literature:

[1] Z. Bao, A. J. Lovinger, J. Brown, *New air-stable n-channel organic thin film transistors*, J. Am. Chem. Soc. 1998, 120, 207
[2] F. Schreiber, *Structure and growth of self assembling monolayers*, Prog. in Surf. Sci. 2000, 65, 151
[3] S. R. Forrest, *Ultrathin organic films grown by organic molecular beam deposition and related techniques,* Chem. Rev. 1997, 97, 1793
[4] J. O. Ossó, F. Schreiber, V. Kruppa, H. Dosch, M. Garriga, M. I. Alonso, F. Cerdeira, *Controlled molecular alignment in phthalocyanine thin films on stepped sapphire surfaces*, Adv. Func. Mat. 2002, 12, 6+7, 455
[5] J. O. Ossó, F. Schreiber, M. I. Alonso, M. Garriga, E. Barrena, H. Dosch *Structure, morphology, and optical properties of thin films of F_{16}CuPc grown on silicondioxide,* Organic Electronics, in press
[6] D. G. de Oteyza, E. Barrena, J. O. Ossó, H. Dosch, to be published

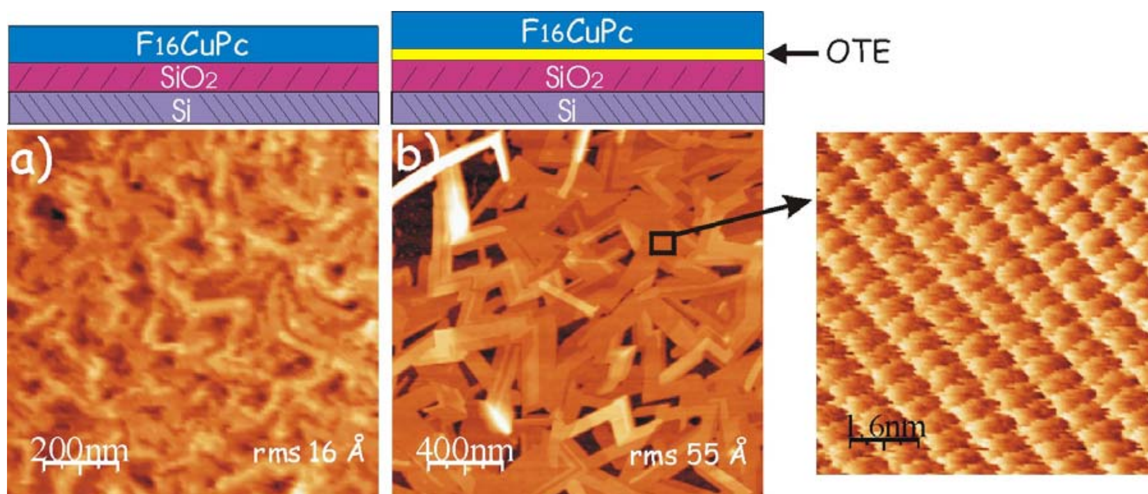

Fig. 1) AFM images of the 100 Å thick films on SiO_2 (a) and OTE (b) and AFM resolved molecular order on the sample on OTE. On top, schema of the two different samples.