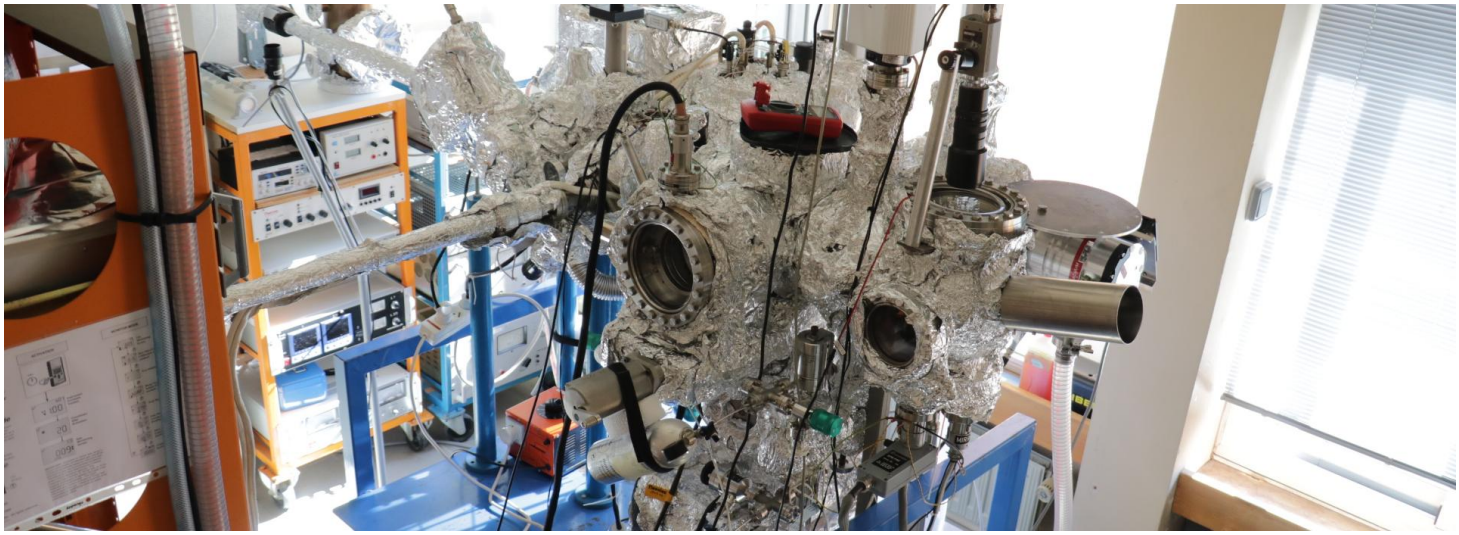
Investigating Molecule-Substrate Charge Transfer with Scanning Probe Microscopy.



Organic thin films are important materials in research and industry since they offer unique electronic, optical and mechanical properties. To obtain organic films with specific properties, well-designed molecules and support materials as well as ideal parameters for the film growth and in turn for the adsorption and a possible ordered *self-assembly*. An important impact has the adsorption of the molecules, which is determined to a large extend by the molecule-support interaction. On strongly interacting surfaces like the ones of metals, a thin insulating (oxide) film is mostly used such that it separates the molecules from the metal surface and therefore weakens the strong interaction with the metal (no hybridization), guaranteeing, e.g., a better self-assembly. However, it may happen that, intrinsically, an integer number of electrons tunnel between the conducting support and the molecules (ICT: *integer charge transfer*) [1,2], which has a high impact on the electronic and structural properties of the assembly. In particular, when the work function (WF) of the support is small and the electron affinity (EA) of the molecules is high, an electron transfer from the support to the molecules can appear, as recently shown with PTCDA molecules on MgO(001)/Ag(001) substrates [3]. And vice-versa, with a high WF of the support, a transfer of electrons may take place from the molecules to the support, as shown with 2H-phthalocyanine molecules on MoO_3/Pd(001) substrates [4]. In general, such transfer of charges to or from molecular films opens new perspectives in organic thin films, however, to date, there are still few examples where ICT phenomena as such have been deciphered and entirely characterized, and further film systems need to be studied in future.

The objective of the fundamental research work here is to study the adsorption (self-assembly) of molecules on metal supported ultra-thin cerium oxide (ceria) films and to characterize possible intrinsic charge transfer phenomena and related electronic and geometric changes of the film. The charge transfer phenomena shall be studied in dependence on the ceria/metal work function (change of ceria's oxidation state, different metal supports) and by considering different molecules. Ceria is a very important reducible oxide material that finds its industrial application in heterogeneous catalysis and nanotechnology. The self-assembly will be studied by scanning tunneling microscopy (STM), noncontact AFM (nc-AFM) and in particular by Kelvin probe force microscopy (KPFM) under ultra-high vacuum (UHV) conditions. While STM and nc-AFM will be used to reveal the surface structure and morphology determined by the self-assembly of the molecules, the task of KPFM will be to monitor the local surface work function (WF), providing a quantitative measure for charge transfer processes. Scanning tunneling spectroscopy (STS) on the contrary will be used to analyze the detailed electronic structure of the surface.

We search a PhD student who is going to help us with our work. The candidate will work alternately with a low and room-temperature microscope, which both can work either in the STM, nc-AFM or KPFM mode as well as in diverse spectroscopy modes. Photoemission experiments can be optionally done within the PRISM facility of our institute. Funding for the doctoral program is subject to a selection process by the local university and the Ministry of Education and is therefore not yet guaranteed. The salary will be comparable to standard European PhD salaries. According to prior agreement, the work may start in October 2026.

The PhD candidate should have a master degree in physics/nanoechnology and should have therefore a knowledge of physics and mathematics as well as in nanotechnology. Knowledge of English is absolutely welcome.

We offer an interesting work in the important field of molecular self-assembly and surface science in conjunction with leading surface science techniques like STM, nc-AFM and KPFM. Our institute is located in a beautiful region of the Provence offering many possibilities to enjoy nature and the Mediterranean Sea. Alongside French, we speak also English and German.- Requests with information about the candidate (CV, final grades, eventual publications, etc.) should be addressed to:

Dr. Clemens Barth and Dr. Thomas Leoni
Aix-Marseille Université / CNRS
CINaM UMR 7325
13288 Marseille 09
France
Email : clemens.barth@cnrs.fr
thomas.leoni@univ-amu.fr

Tel. : ++33.(0)6.60.36.28.19
++33.(0)6.62.92.28.39
CINaM : https://www.cinam.univ-mrs.fr/cinam/

Literature

Literature and a more detailed project description can be sent on request.

[1] H. Ishii *et al.*, *Adv. Mater.* **11** (1999) 605– 625.
[2] S. Braun *et al.*, *Adv. Mater.* **21** (April 2009) 1450–1472.
[3] P. Hurdax *et al.*, *J. Phys. Chem. C* **129** (2025) 1553−1561.
[4] M. Niederreiter *et al.*, *J. Phys. Chem. C* **129** (2025) 18822−18830.
For further reading
[3] B. Hoff et al., J. Phys. Chem. C 118 (2014) 14569.
[4] C. Barth, J. Phys. Chem. C 129 (2025) 6762.
[5] T. Leoni et al. Phys. Rev. Lett 106 (2011) 216103.