2024-2025

Master thesis proposal

Campus Pierre et Marie Curie
Tower 23 – 3rd floor – 23-22
Director: Massimiliano Marangolo

Title: Formation of alumina films at the $Fe_{0.85}Al_{0.15}$ surface beyond the pressure gap

Keywords: alumina films, surface science approach of oxidation

Scientific description:

Galvanization faces a new paradigm with the modern light-alloy grades developed by steel manufacturers to comply with the environmental constraints of the car industry. The unwanted selective segregation and oxidation at steel surfaces of the light electropositive elements such as Al during processing prevents the good adherence of the Zn anti-corrosive coating. In this industrial context in collaboration with the steel company ArcelorMittal, our INSP group has developed a fundamental surface science approach for the selective oxidation at the surfaces of $Fe_{0.85}Al_{0.15}$ single crystals. As seen by photoemission, samples annealed under vacuum have a surface enriched in aluminum with complex reconstructions that depend on the crystallographic orientations [1]. The high-temperature oxidation at low pressures leads to the formation of self-limited bilayer films of alumina on the (110) orientation, the structures of which have no bulk counterpart [2] (Figure). With such a preparation, iron always keeps its metallic state. However, industrially, the growth of nanometric films of γ-Al_2O_3 are observed at the surface of alloyed steel.

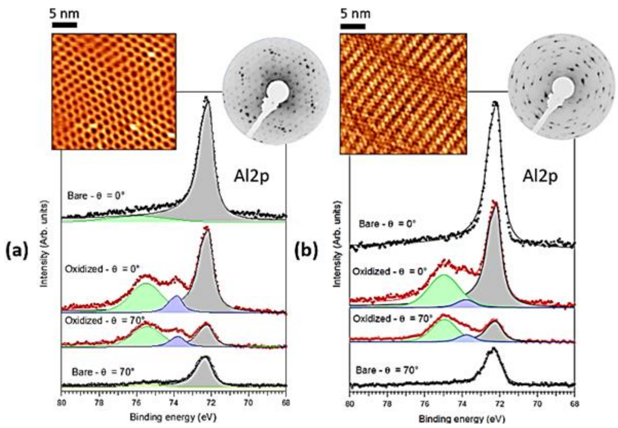

Figure : Fingerprints of the alumina thin films found at $Fe_{0.85}Al_{0.15}$(110) surface as evidenced by STM, LEED and XPS of Al 2p core-level. Two different phases are encountered depending on surface preparation

The aim of the internship is to bridge the pressure gap between academia and industry using a newly developped high-pressure cell connected to the INSP vacuum system. By combining near-field microscopy (morphology up to atomic resolution), X-ray photoemission spectroscopy (chemical states, stoichiometry, thickness, segregation profile) and low-energy electron and X-ray diffractions (crystallographic structure), the effect of environment during oxidation and of crystal orientation [(110) vs (100)] will be scrutinized to understand the oxide thickening and the evolution of its atomic structure.

Z. Dai, N. Alyabyeva, M. Van den Bossche, P. Borghetti, S. Chenot, P. David, A. Koltsov, G. Renaud, J. Jupille, G. Cabailh, C. Noguera, J. Goniakowski, R. Lazzari, [1] Appl. Surf. Sci., 444 (2018) 457, Appl. Surf. Sci., 492 (2019) 886-895, App. Surf. Sci 509 (2020) 155312 (2020) and [2] Phys. Rev. Mat. 4, 074409 (2020), submitted (2021)

Techniques/methods in use: Photoemission, Scanning Tunnelling Microscopy, Low Energy Electron Diffraction, X-ray diffraction

Applicant skills: Good background in material science and solid-state physics with a strong taste for experiments.

Industrial partnership: ArcelorMittal-Maizières-Research but not directly involved in the internship

Internship supervisor(s): Lazzari Rémi, remi.lazzari@insp.jussieu.fr, 01 44 27 46 28 (23 16); Gregory Cabailh, gregory.cabailh@insp.jussieu.fr, 01 44 27 44 43 ; Anna Levy, anna.levy@insp.jussieu.fr, 01 44 27 23 55

Internship location: Institut des NanoSciences de Paris, CNRS/Sorbonne Université, 4 Place Jussieu, 75005 Paris

Possibility for a Doctoral thesis: Y (application to ED397)