'Physique et Chimie des Matériaux' – ED 397 – année 2022

PhD project for funding, to send by 28/02/2022 to

nadine.witkowski@sorbonne-universite.fr under PDF form « acronyme labo_nom PI.pdf »

Research unit (full name + acronym) : Institut des NanoSciences de Paris / INSP

Team if applicable : Low-dimension oxides

Address : 4 Place Jussieu, 75005 Paris

Project leader (PI): Rémi Lazzari HDR? yes Position : Researcher CNRS

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Nber of phD under supervision 2 Participation to supervisor training? no Year

Co-supervisor : Grégory Cabailh HDR? no Position : Lecturer SU

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Research unit : Institut des NanoSciences de Paris / INSP

International co-supervision ? No

Keyword 1 : surface science Keyword 2 : FeAl alloy oxidation

Keyword 3 : alumina Keyword 4 : STM, photoemission,diffraction

Select co-funding programme if applicable : select

Project title : Formation of alumina thin films at the FeAl surface beyond the pressure gap

Project 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 of the light electropositive elements such as Al at steel surface during high temperature processing prevents the good adherence of the Zn anti-corrosive coating. In this industrial context in collaboration with ArcelorMittal steel company, our INSP group has developed a fundamental surface science approach of the selective oxidation at the surfaces of model Fe0.85Al0.15 single crystals. As seen by photoemission, samples annealed under vacuum have a surface enriched in Al with complex reconstructions that depend on the crystallographic orientations [1-3]. The high-temperature oxidation at low pressures (compatible with studies under ultra-high vacuum) leads to the formation of self-limited bilayer films of alumina on the (110) orientation, the structures of which have no bulk counterpart [4-5] . Iron always keeps its metallic state. However, industrially, the growth of nanometric films of gamma-Al2O3 is observed at the surface of alloyed steel at low dew point and a transition towards internal oxidation at higher value.

The aim of this PhD thesis is to bridge the pressure gap between academia and industry using a dedicated high-pressure chamber connected to the INSP vacuum system and an oxygen-plasma cell. By combining near-field microscopy (morphology up to atomic resolution), X-ray photoemission spectroscopy (chemical states, stoichiometry, thickness, profile of segregation) and low-energy electron and X-ray diffractions (crystallographic structure), the effect of environment during oxidation and of crystal orientation [(110), (100), (111)] will be scrutinized to understand the oxide thickening and the evolution of its atomic structure. Complementary experiments of diffraction and photoemission at synchrotron will help unravelling the underlying mechanisms and the exact structure of the formed films.

The interested candidate should have a good background in material science and solid state physics with a strong taste for experiments.

[1] Self-organized carbon-rich stripe formation from competitive carbon and aluminium segregation at Fe0.85Al0.15(110) surfaces
Z. Dai, P. Borghetti, Y. Mouchaal, S. Chenot, P. David, J. Jupille, G. Cabailh, R. Lazzari, Appl. Surf. Sci., 444, 457 (2018)
[2] Aluminium segregation profiles in the (110), (100) and (111) surface regions of the Fe0.85Al0.15 random body-centered cubic alloy
Z. Dai, P. Borghetti, S. Chenot, P. David, J. Jupille, G. Cabailh, J. Goniakowski, R. Lazzari, Appl. Surf. Sci., 492, 886-895 (2019)
[3] Al-rich Fe0.85Al0.15 (100), (110) and (111) surface structures
Z. Dai, N. Alyabyeva, P. Borghetti, S. Chenot, P. David, A. Koltsov, G. Renaud, J. Jupille, G. Cabailh, R. Lazzari, App. Surf. Sci 509, 155312 (2020)
[4] Oxide at the Al-rich Fe0.85Al0.15 (110) surface
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, Phys. Rev. Mat. 4, 074409 (2020)
[5] Bistability of ultra-thin alumina films at the Fe0.85Al0.15(110) surface
N. Alyabyeva, S. Chenot, P. David, J. Jupille, G. Cabailh, A. Koltsov, R. Lazzari, submitted (2022)