

Soft X-Ray spectroscopy at liquid/solid interface: in-situ and operando investigations at BACH beamline

S. Nappini¹, I. Napal Azcona^{1,2}, I. Piš¹, F. Bondino¹, and E. Magnano^{1,3}

¹IOM-CNR, Basovizza, Trieste, 34149, Italy

²Department of Physics, Trieste University, Trieste, 34127, Italy

³Department of Physics, University of Johannesburg, Johannesburg 2006, South Africa

The CNR Beamline for Advanced Circular dichroism (BACH) operating at the Italian synchrotron radiation facility Elettra in Trieste, works in the EUV-soft x-ray photon energy range with selectable light polarization, high energy resolution, brilliance and time resolution. The beamline offers a multi-technique approach for the investigation of electronic, chemical, structural, magnetic and dynamical properties of materials [1].

One of the research activities on the beamline is dedicated to experiments based on electron transfer processes at the solid/liquid interfaces during photocatalytic or electrochemical reactions.

The encapsulation of liquid solution between a graphene layer and a solid substrate was successfully applied to the study of temperature [2] and photo-induced reactions [3] by X-ray photoemission spectroscopy (XPS) and X-ray absorption spectroscopy (XAS). A second approach is based on the use of cells consisting of a thin Si₃N₄ membrane, which separates the liquid from the vacuum. We developed different types of cells, static cells working in transmission or in fluorescence yield, and electrochemical flow cells to carry out in-situ cyclic voltammetry and electrodeposition on a working electrode and to study electrocatalytic reactions under operando conditions [4]. XAS in fluorescence or in total electron yield modes is used for the electronic characterization, providing unique information with elemental sensitivity of the chemically active atomic orbitals of the material.

In the talk I will present some examples of experiments performed under ambient conditions and during electrochemical experiments in liquids, as well as the recent technical developments and the perspectives on BACH beamline.

[1] M. Zanfranco, M. Zacchigna, M. Finazzi, D. Cocco, R. Rochow, F. Parmigiani, *Rev. Sci. Instrum.* 75, 31 (2003)

[2] S. Nappini, A. Matruglio, D. Naumenko, S. D. Zilio, F. Bondino, M. Lazzarino, and E. Magnano, *Nanoscale* 9, 4456 (2017)

[3] S. Nappini, A. Matruglio, D. Naumenko, S. Dal Zilio, M. Lazzarino, F. M. F. De Groot, C. Kocabas, O. Balci, E. Magnano, *Journal of Physical Chemistry C*, 121, 22225 (2017)

[4] S. Nappini, L. D'Amario, M. Favaro, S. Dal Zilio, F. Salvador, E. Betz-Güttner, A. Fondacaro, I. Piš, L. Romanzin, A. Gambitta, F. Bondino, M. Lazzarino, E. Magnano, *Review of Scientific Instruments*, 92, 015115 (2021)