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Assessment of dye distribution in sensitized solar cells by microprobe techniques

BARREIROS, M. Alexandra 1; CORREGIDOR, Victoria 2; ALVES, Luis 2; GUIMARAES, Fernanda 3; SEQUEIRA, Sara 1; MASCARENHAS, João 1; TORRES, Érica 1; BRITES, M. Joao 1
1 Laboratório Nacional de Energia e Geologia, LNEIES, Portugal
2 Campus Tecnológico e Nuclear, IST, Universidade de Lisboa, Bobadela LRS, Portugal
3 Laboratório Nacional de Energia e Geologia, LGM/ICTM, Portugal

Corresponding Author: alexandra.barreiros@lneg.pt

Dye sensitized solar cells (DSC’s) have received considerable attention once this technology offers economic and environmental advantages over conventional photovoltaic (PV) devices. A DSC photoanode typically consists of a nanocrystalline porous TiO2 film, endowed with a large adsorptive surface area. Dye molecules that capture photons during device operation are attached to the film nanoparticles. The effective loading of the dye in the TiO2 electrode is of paramount relevance for controlling and optimizing solar cell parameters. In particular, the cell short-circuit current density (Jsc) is directly proportional to the light harvesting ability of the photoanode, which in turn is strictly dependent on the dye concentration on the TiO2 adsorptive surface. In addition, the dye adsorption behavior affects the cell open circuit voltage (Voc).

Relatively few methods are known today for quantitative evaluation of the total dye adsorbed in the film. In this context microprobe techniques come out as suitable tools to evaluate the dye distribution and dye depth profile in sensitized films.

Electron Probe Microanalysis (EPMA) and Ion Beam Analytical (IBA) techniques using a micro-ion beam were used to quantify and to study the distribution of the ruthenium organometallic (N719) dye in TiO2 films, making use of their different penetration depth and beam sizes. Two different types of films were prepared and sensitized, mesoporous nanoparticles and 1D nanostructured TiO2 films (about 4 µm thickness).

The high sensitive analytical techniques used allowed to assess dye surface distribution and depth profile, by means of Ru signal, despite the low concentration of this element. X-ray mapping by EPMA/WDS technique made possible to visualise the dye distribution in sample cross-section. PIXE maps of Ru and Ti indicated an homogeneous surface distribution. The assessment of ruthenium depth profile by RBS showed that some films have homogeneous Ru depth distribution while others presented up to half of the Ru concentration in the top layer (2 µm thickness) when compared to the lower one.

Dye load evaluation in different TiO2 films by two different techniques (µPIXE and EPMA/WDS) provided similar results of Ru/Ti.

The assessment of the dye distribution and quantification across an oxide semiconductor film by microprobe techniques can lead to a better understanding of the device performance.