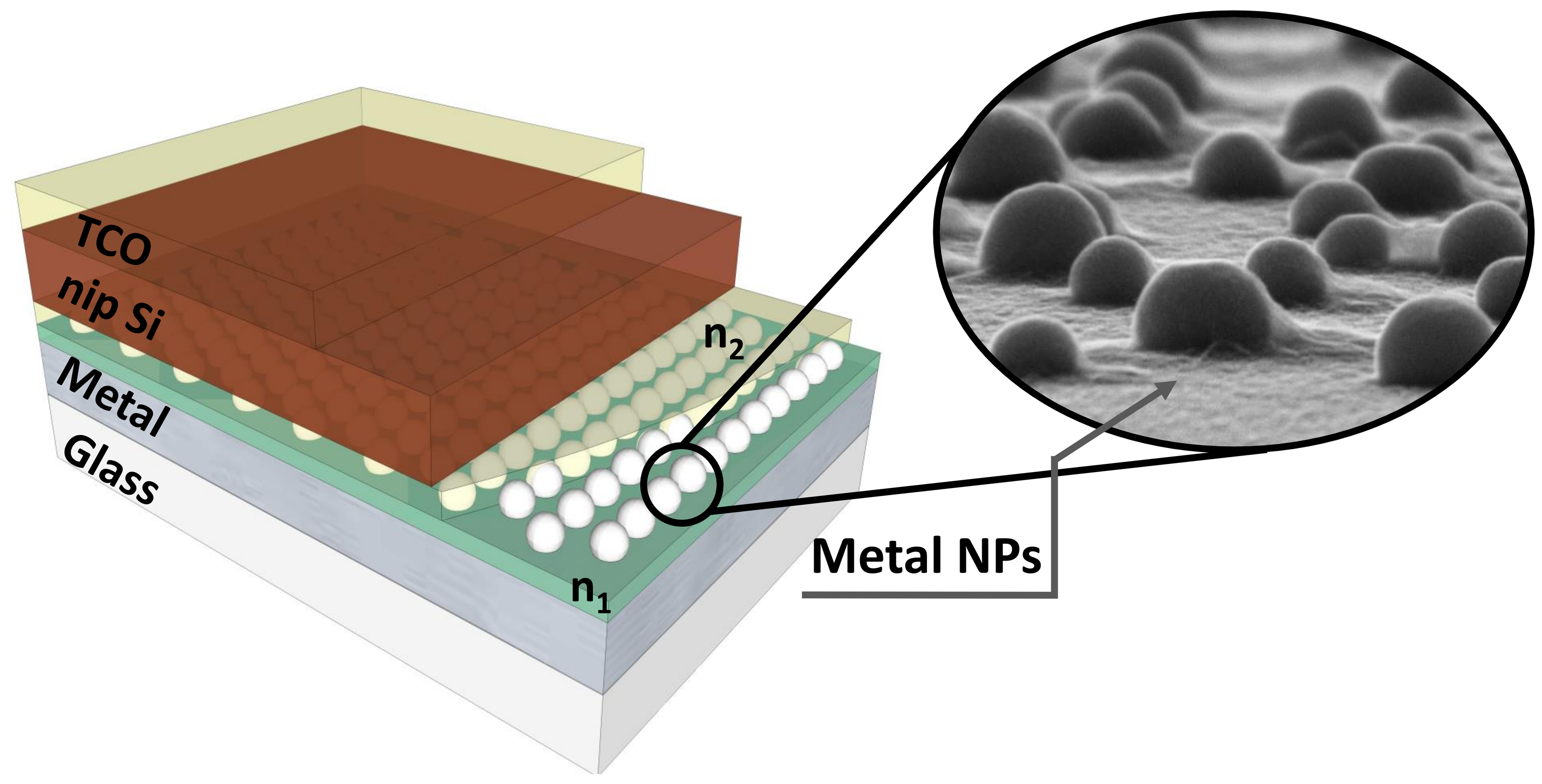
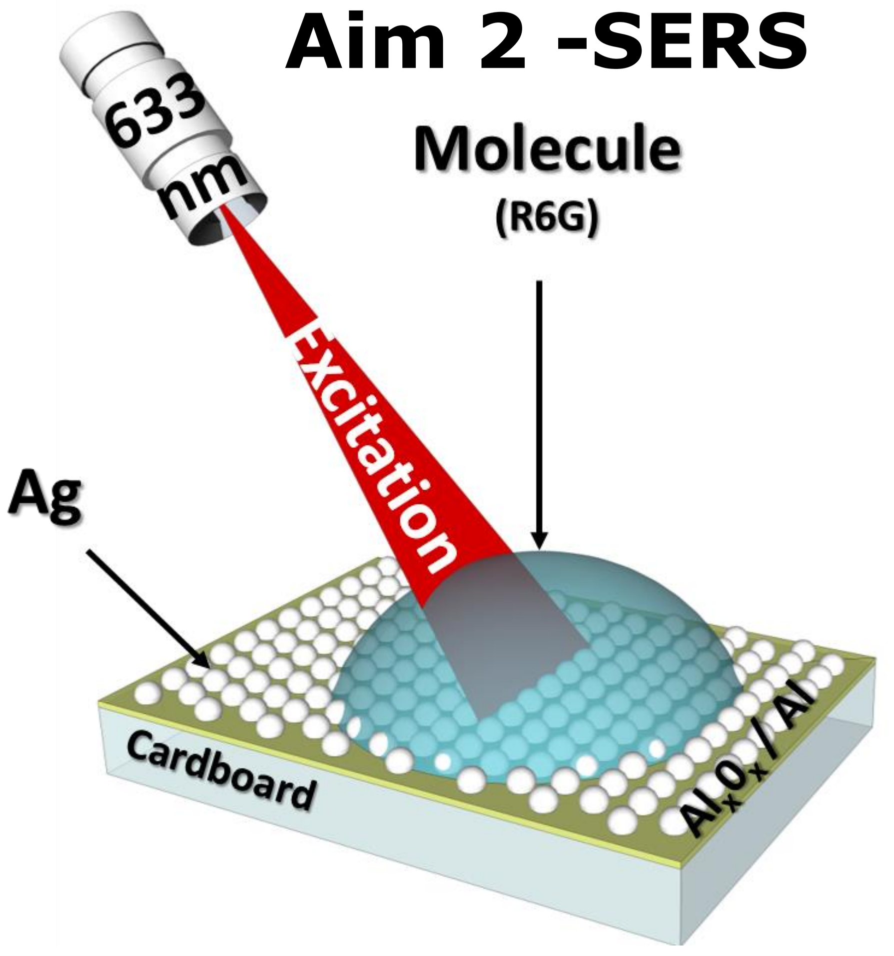
CENIMAT – Materials Research Centre, New University of Lisbon

METAL NANOPARTICLES FOR PLASMON-ENHANCEMENT IN SI SOLAR CELLS AND RAMAN SPECTROSCOPY

AIM 1 - Si Solar Cells



Aim 2 -SERS



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Objectives

Metallic nanostructures supporting surface plasmons have been proposed as an alternative method to achieve enhancement in Si solar cells and also Surface Enhanced Raman Spectroscopy (SERS). When metal nanoparticles (NPs) are excited by electromagnetic radiation of appropriate energy, their conduction electrons oscillate collectively exhibiting Localized Surface Plasmon Resonance (LSPR).The incident light near the resonance frequency can be resonantly absorbed or scattered by the nanoparticles, creating a propagating far-field localized near-field , depending on their physical parameters (size, shape and distance between them and the surrounding environment). In this work we explore the physical properties of silver (Ag) nanoparticles that can be best suited for each of these applications.

Methods and techniques

Metal nanoparticles (MNPs) were obtained by metal evaporation using an electron-gun assisted thermal evaporation technique. To form the MNPS, the process occurred at temperatures ranging from 150°C up to 500°C and for different atmospheric mediums. For Aim 1 Ag NPs are formed in situ during the thermal evaporation of thin films of silver onto cardboard packaging substrates heated at 150 ºC. On the other hand, in Aim 2 plasmonic structures were obtained through the deposition of Ag thin-films followed by annealing @ 500 °C using the Rapid Thermal Annealing (RTA) system (Fig. 1). The morphological characterization of the NPs were obtained by SEM and AFM and the optical responses were obtained with a double beam UV-VIS-NIR spectrometer (Lambda 950) equipped with an integrating sphere, in the range of 300-1500 nm.

Results

AIM 1: Explore the physical properties of Ag NPs for SERS applications. In this work, we developed a new kind of cost-efficient SERS substrate using Rhodamine 6G (R6G) as Raman probe (Fig. 2). Ag mass-equivalent layer thickness ranging from 2 to 8 nm were outlined. Enhancement factor (EF) data show that an average enhancement as high as 1×106 is achieved for the nanoplasmonic cardboard SERS substrate obtained from 6 nm Ag mass thickness. This is attributed to: optimal spectral matching of the plasmonic resonance (λLSPR = 660 nm) and high local electric field enhancement produced by the 60 nm-sized Ag NPs.

AIM 2: Development of Ag NPs that due to their plasmonic scattering properties, increase the light path in the active layer of the solar cell contributing to an improvement of the solar cell efficiency (Fig.3). we report dewetting based fabrication and optical responses of AgNPs on 5 different oxides solar cell technology relevant material surfaces which are widely used, namely ZNO, AZO, GZO and In doped ZnO (AZO). From the analysis of SEM images it was found that both the size and inter-particle distance increase significantly for NPs formed on AZO substrate. The shape of the AgNPs appears to be more spherical, homogenous and higher in size for AZO substrate than the AgNPs on other substrates for same annealing temperatures. In the case of AZO we observed as large as 400 nm particle sizes after annealing at 500 °C.

Publications

Andreia Araújo*, Carlos Caro, Manuel J Mendes, Daniela Nunes, Elvira Fortunato, Ricardo Franco, Hugo Águas and Rodrigo Martins, Highly efficient nanoplasmonic SERS on cardboard packaging substrates, Nanotechnology 25 (2014) 415202.

Andreia Araújo*, Raquel Barros, Tiago Mateus, Diana Gaspar, Nuno Neves, Antonio Vicente, Sergej A Filonovich, Pedro Barquinha, Elvira Fortunato, Ana M Ferraria, Ana M Botelho do Rego, Ana Bicho, Hugo Aguas and Rodrigo Martins, Role of a disperse carbon interlayer on the performances of tandem a-Si solar cells, Sci. Technol. Adv. Mater. 14 (2013) 045009.

Fig. 1 - PBRs with Ag nanoparticles formed by thin-film annealing

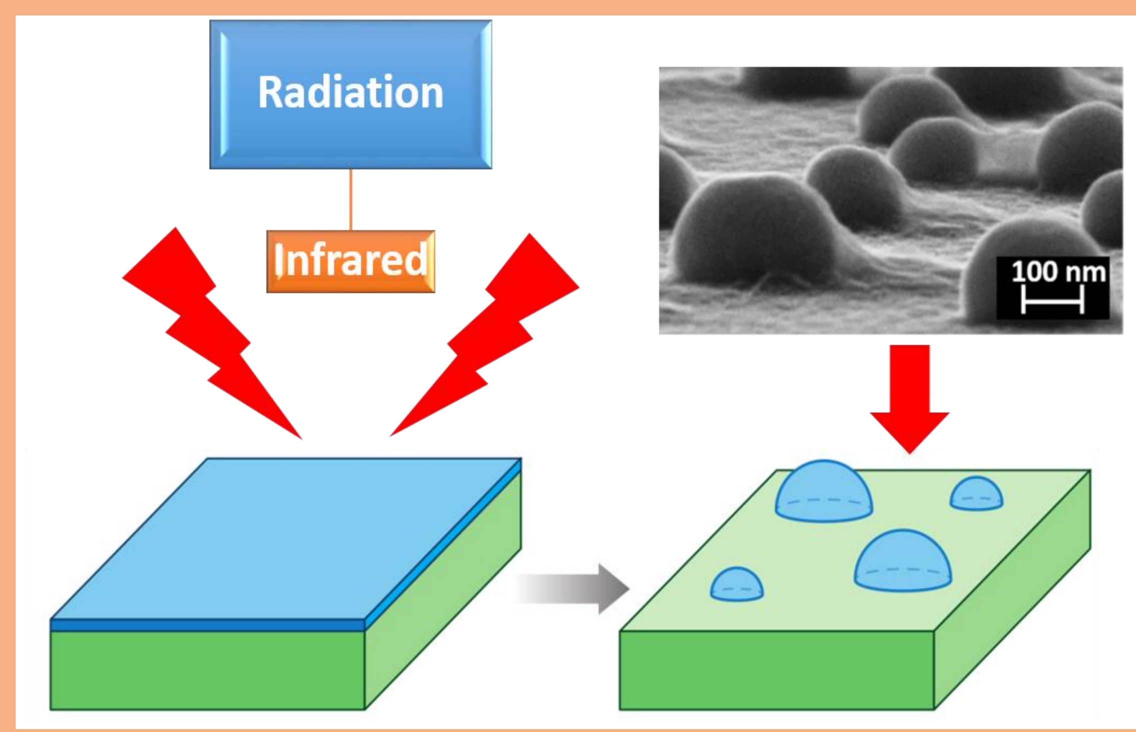


Fig. 2 – Ag Nanoplasmonic cardboard SERS substrate used in the detection of R6G

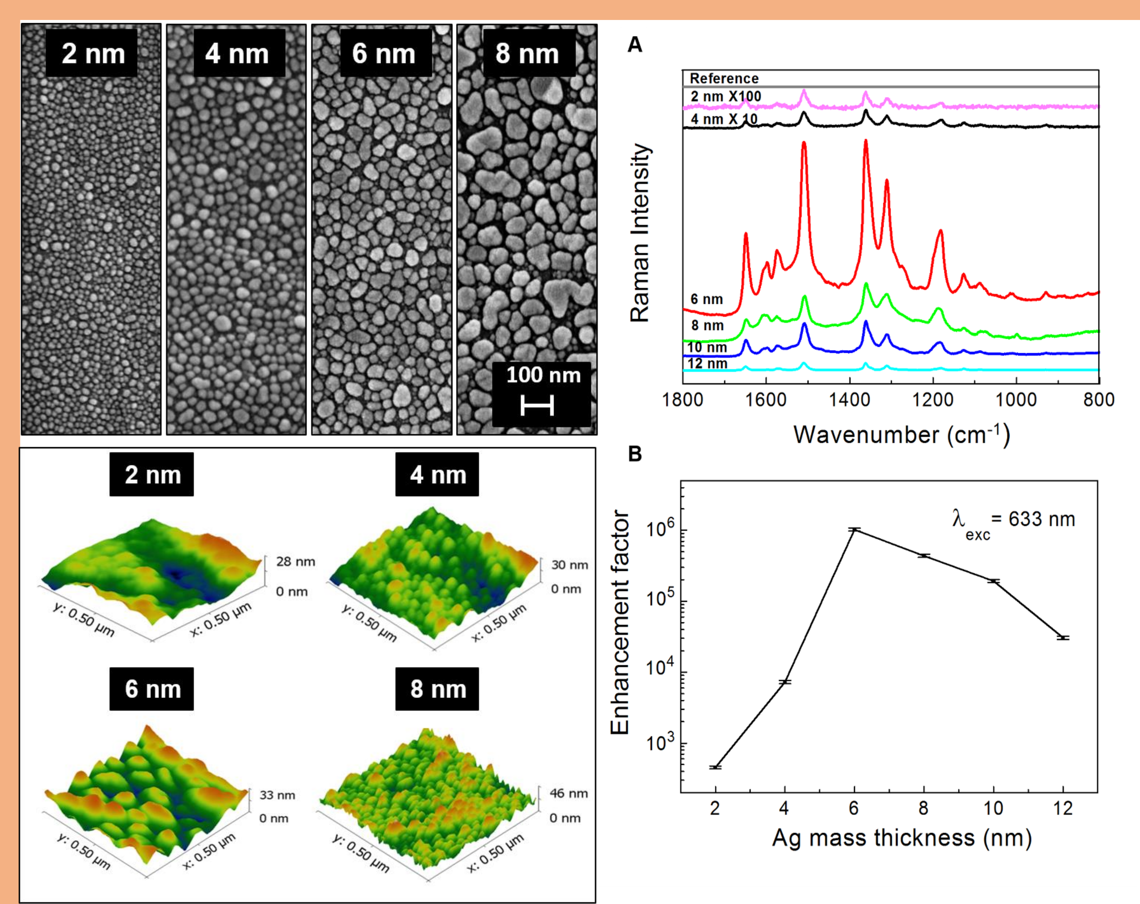
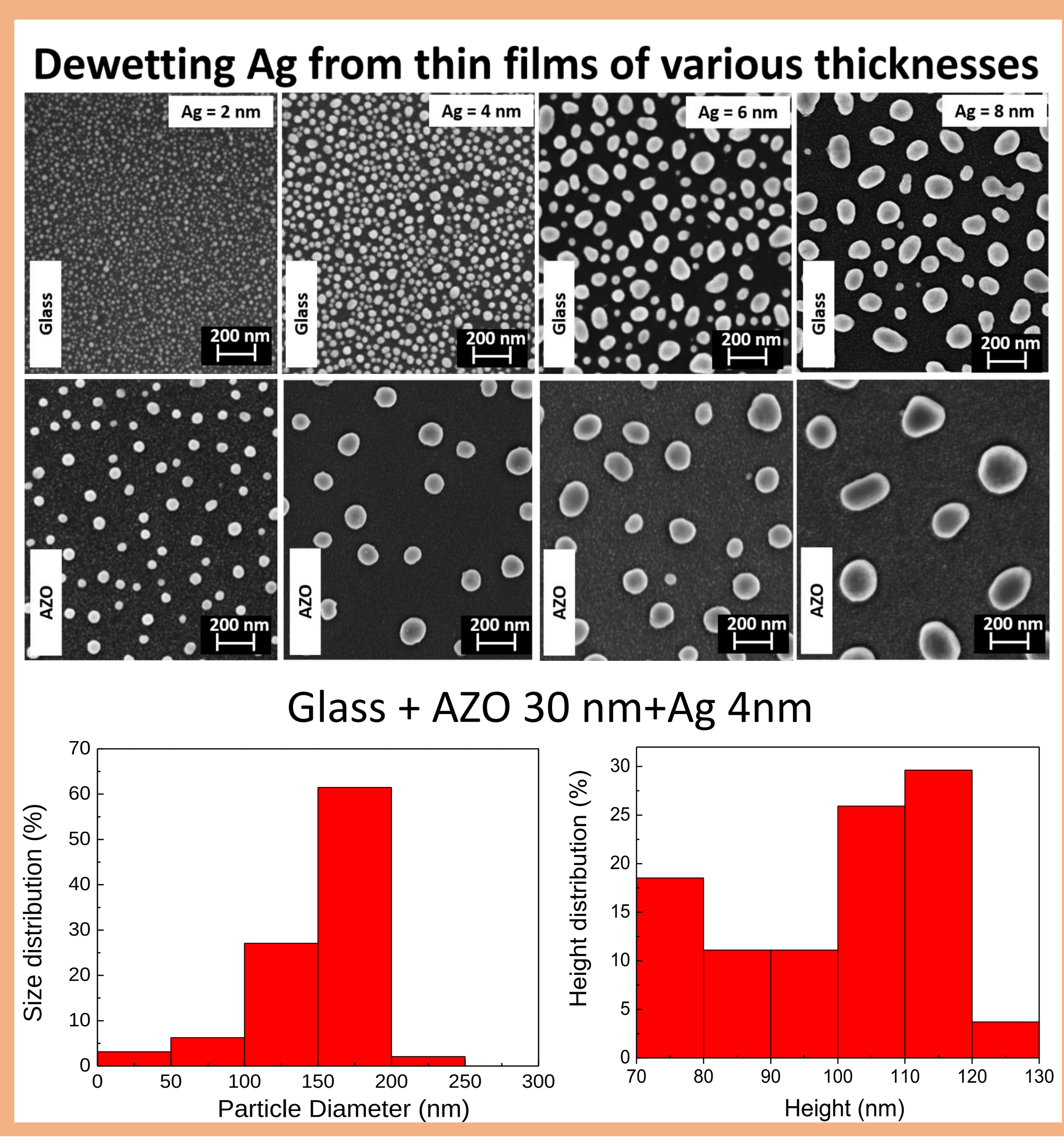


Fig. 3 –AgNPs for Si Solar cells



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