Objectives
Metallic nanostuctures 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°C. On the other hand, in Aim 2 plasmonic structures were obtained through the deposition of Ag thin-films followed by annealing at 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 1×10^6 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 (∆LSPR = 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 interparticle 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