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Hydrogenated amorphous carbon with embedded plasmonic NPs of silver/gold: nanocomposite films for selective and broadband optical absorption

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Abstract: The ability of plasmonic nanoparticles (PNPs) to absorb localized parts of the visible and infrared spectra depending on their size, shape and surrounding media are here explored for selective and broadband optical absorption applications, i.e. as potential solar harvesting materials collecting the sunlight energy that in turn heats a convective medium. Most of the materials currently in use exploit only a part of the solar radiation, leaving a great proportion unexplored. We here report on the making, measuring and modelling (previously designated as the 3M's principle) of hydrogenated amorphous carbon (a-C:H) matrices with PNPs (Ag and Au) to generate nanocomposite films with localized and tunable surface plasmon resonance (LSPR) characteristics and enhanced absorption capabilities. Free standing nanoparticles (NPs) of Ag and Au have been synthesized by thermally dewetting magnetron-sputtered films which have been subsequently capped with a layer of a-C:H. The NPs size was controlled through deposition time and annealing parameters. The a-C:H layer was deposited through an ion-beam source by cracking methane molecules using an RF plasma source. The morphological characteristics of the NPs have been investigated with SEM and AFM whereas optical measurements have been collected with a UV/VIS spectrophotometer. Roughness, density and thickness of the nanocomposite films have been probed using X-ray reflectivity. The factors that affect the LSPR peak position such as NP size, annealing conditions and host environment have been investigated, modelled and quantified. Finally, the solar photothermal performance of the produced films was evaluated in realistic conditions, using a thermocouple data logger system and monitored in real-time under sunlight. The experimental results are contrasted to photo-thermal theoretical predictions based on the effective medium theory.