ABSTRACT

Thesis work focused on light confinement into silicon solar cells by adopting plasmonics concepts along with the conventional approaches (surface texturing and antireflection dielectric coating on silicon surface) using different metal and hybrid nanostructures comprised of self-assembled silver, aluminum, silver-aluminum alloy nanoparticles, and also metal nanoparticles embedded in different dielectric environment for device performance improvement. The silver nanoparticles on SiO$_2$ thin films of variable thickness as a plasmonic double layer investigated for broadband antireflection from the silicon. With optimized SiO$_2$/silver nanoparticles, the reflectance reduced to 3.5% in 725-1020 nm wavelength region. Further, the aluminum nanoparticles explored as cost-effective light forward scatterers. The photocurrent enhancement of 8.6% achieved from silicon solar cell with self-limiting native oxide shell on the aluminum nanoparticles in comparison to bare cell due to improvement in light forward scattering. Next, a hybrid plasmonic structure comprised of silver-aluminum alloy nanoparticles embedded in different dielectric matrices investigated to minimize the optical losses. An average optical reflectance of 3.6% and parasitic absorptance of 4.4% observed in polychromatic spectral region from the optimized hybrid plasmonic structure, which led to cell’s photocurrent enhancement from 34.61 mA/cm$^2$ to 26.27 mA/cm$^2$ of the bare cell. Study related to Fano resonance loss due to the destructive interference from dipole and quadrupole excitation modes hybridization carried out with a different light incident angle for silver nanoparticles integrated silicon wafers of different thicknesses, and found out optimum incident angle of 40° by analyzing experimentally and theoretically to have maximum reflectance reduction from the silicon surface.