OPTIMIZING LIGHT ABSORPTION IN CIGS SOLAR CELLS USING PLASMONIC NANOPARTICLES: VARIATIONS IN MATERIAL, GEOMETRY, AND PLACEMENT

BACHELOR'S THESIS

Written by:

Abi Syaibah
2010441032

Supervisor:
Muldarisnur, Dr.rer.nat., M.Si.
NIP. 198103292008011014

DEPARTEMENT OF PHYSICS
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
UNIVERSITAS ANDALAS
PADANG

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ABSTRACT

This research aims to enhance light absorption in ultra-thin Copper Indium Gallium Selenide (CIGS) solar cells using plasmonic nanoparticles (Au, Al, Ag). The study investigates the effects of nanoparticle material, shape, size, spacing, and positioning within different layers of the solar cells. Computational Finite-Difference Time-Domain (FDTD) simulations were employed. Results indicate that placing nanoparticles (NPs) on the front surface decreases the short-circuit current density (J_{sc}) as NP size increases, with the smallest decrease observed for triangular NPs and the largest for cubic NPs. Aluminum NPs resulted in the highest J_{sc} on the front surface. Conversely, positioning NPs within the active layers increases J_{sc}, with cylindrical NPs achieving a maximum J_{sc} of 30.92 mA/cm². Placing NPs on the back surface also improves J_{sc}, with the most significant enhancement seen in cubic and cylindrical shapes. Aluminum generally provided better performance than silver and gold, except in spherical form. Optimization showed that the optimal NP size is 60 nm and the optimal spacing is 25 nm. The best configuration for maximizing J_{sc} involved using silver cylindrical NPs with a size of 60 nm and spacing of 25 nm, placed within the active layers.

Keyword: CIGS Solar Cells, Plasmonic Nanoparticles, FDTD, Front Surface, Active Layes, Back Surface