Photocurrent enhancement in thin film amorphous silicon solar cells with silver nanoparticles

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Abstract
We include silver nanoparticles in amorphous silicon solar cells to achieve light trapping. Nanoparticles have a size ~200 nm and are embedded in the dielectric at the back reflector. This leads to a remarkable increase in short circuit current of 20% compared to co-deposited cells without nanoparticles. This increase is strongly correlated with the enhanced cell absorption in the long wavelengths and is attributed to localized surface plasmons.

Device and nanoparticles formation

$n-i-p$ solar cell with nanoparticles embedded in the dielectric at the back reflector

SEM image of nanoparticles formed by thermal annealing of a 12 nm silver layer; particle size is ~200 nm

AFM image of nanoparticles: the particle height is around 100 nm

Scattering properties
Silver nanoparticles embedded in a dielectric material have strong scattering properties under light illumination, due to localized surface plasmons.

Absorption enhancement
The increase in short circuit current is strongly correlated with the increase of the cell absorption.

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Conclusion and perspectives

• Nanoparticles are easily formed by thermal annealing of a thin silver layer (10-20 nm).
• Light trapping effect seen with the nanoparticles: gain in $J_{sc}$ of 2 mA/cm$^2$ in an a-Si:H $n-i-p$ solar cell (best gain reported so far).
• Perspectives: better control of the nanoparticles shape and inclusion of nanoparticles in $\mu$-c-Si:H cells.

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