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Photonic Nanostructures for Solar Cell Light Trapping with Colloidal Lithography

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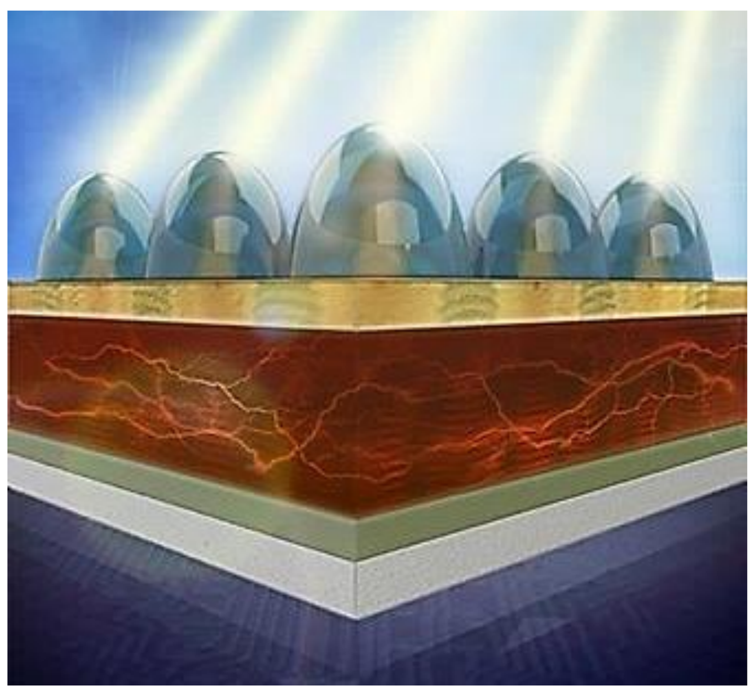
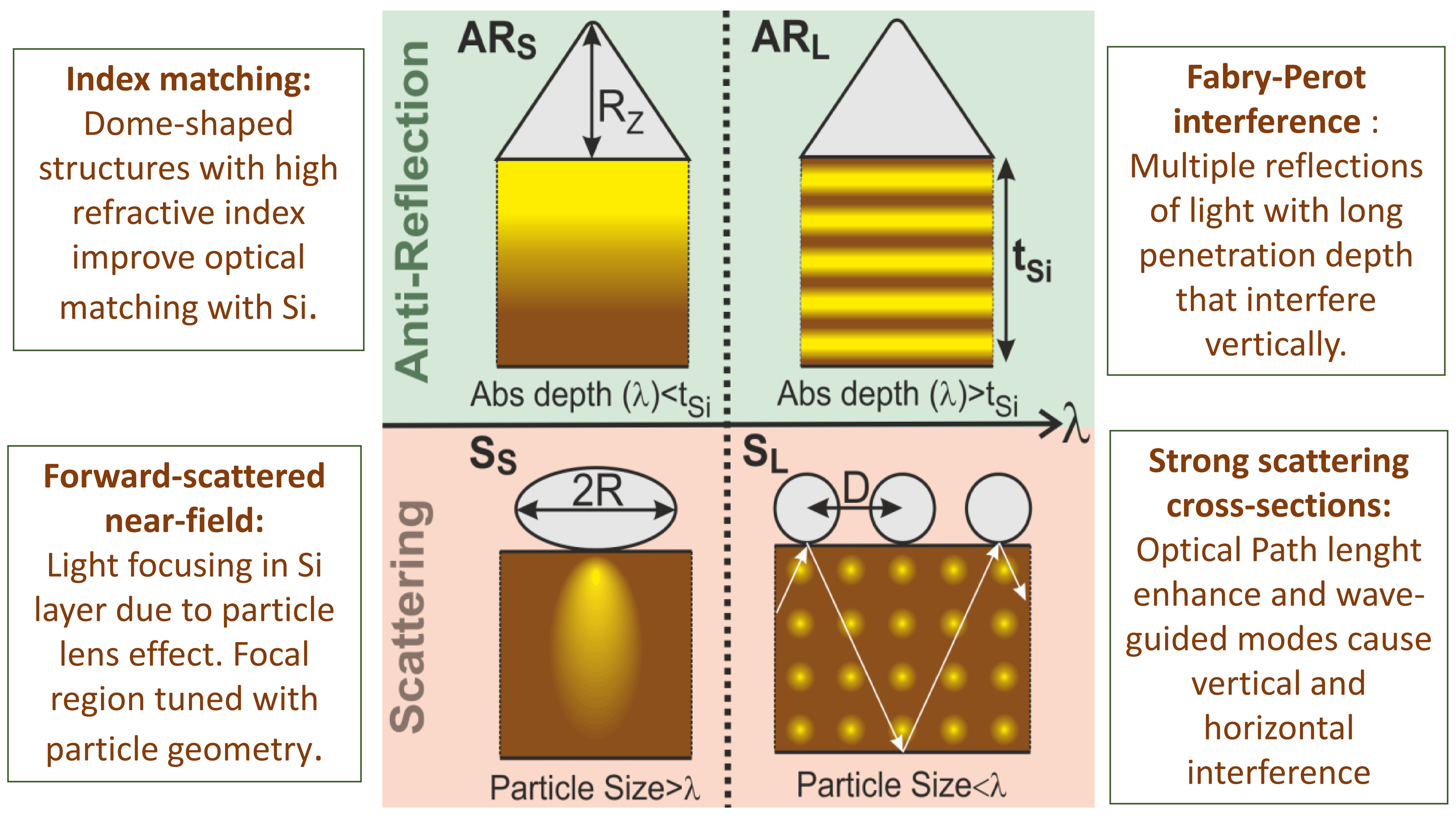
Photonic structures with wavelength-scale dimensions are highly promising for light trapping strategies applied to thin film photovoltaic (PV) devices. When applied on the front transparent contact of solar cells, optimally-shaped high-index dielectric structures can act as high-performing broadband anti-reflectors and scattering elements boosting the light absorption of the cell material along its photo-response spectrum.

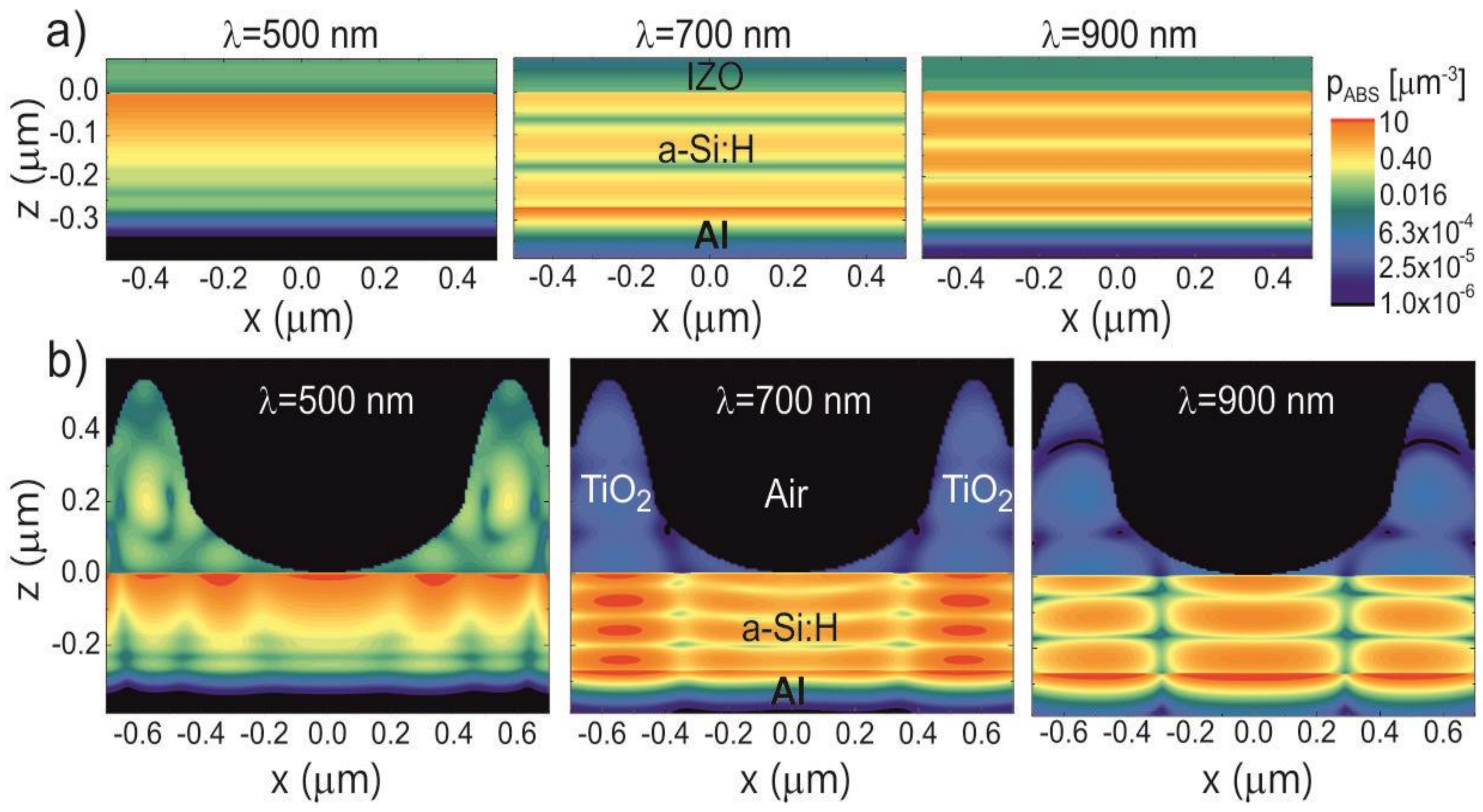
Exact electromagnetic computational optimization shave provided the best parameters of the structures and indicated that TiO_2 is one of the most favorable materials. Therefore, in this work, we present an innovative nanosphere lithography method that allows the precise engineering of TiO_2 wavelength-sized features with the distinct shapes and sizes appropriate for efficient light trapping in different thin film PV devices. This is a simple, low-cost and scalable approach consisting in 4 main steps.



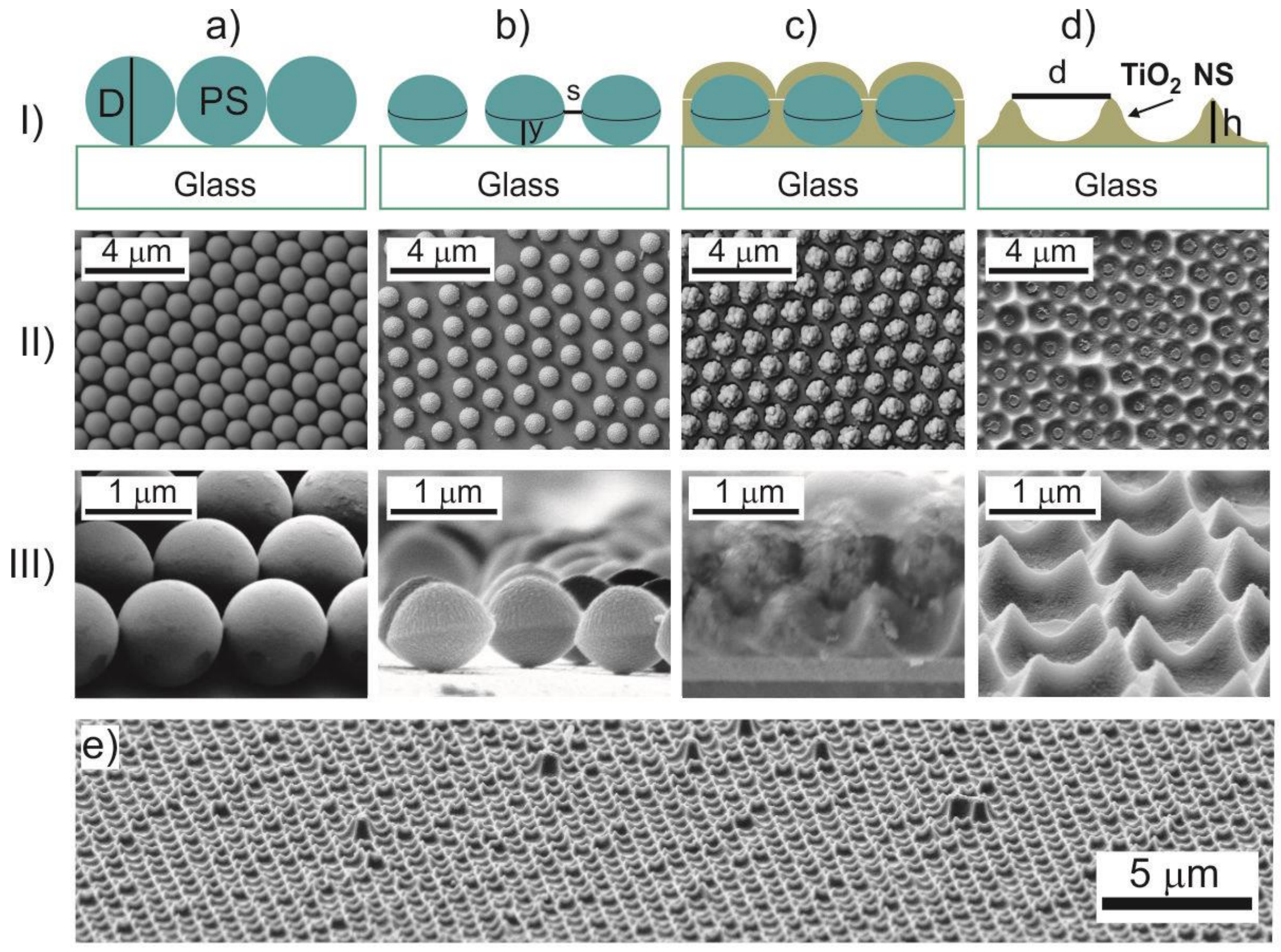
Portrait of optical regimes



FDTD computed absorptance distributions



Colloidal Lithography Process



Nanostructures fabrication steps:

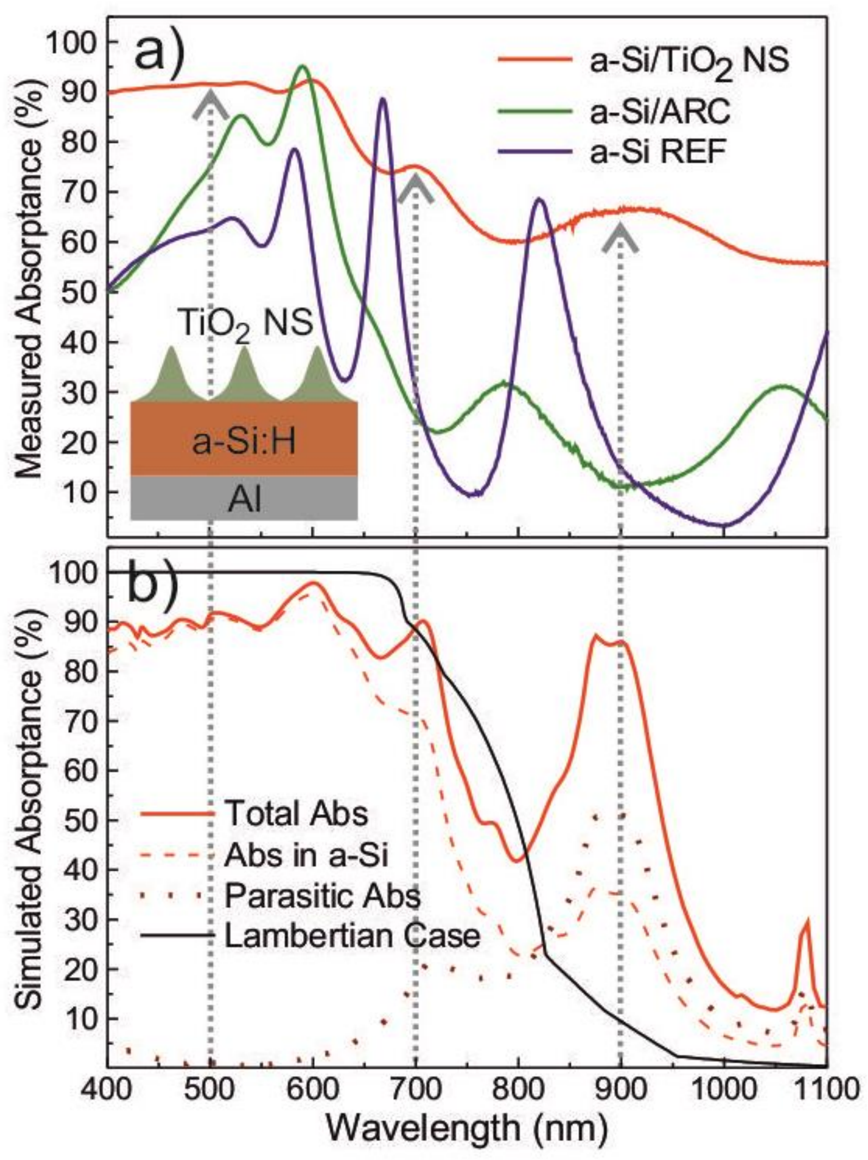
A) *Self-assembly technique:* Deposition of a Polystyrene microspheres (1-2 μm diameter) monolayer by Langmuir-Blodgett

B) *O_2 Dry Etching treatment:* shaping of the spheres and increase of their inter-particle spacing (*s*)

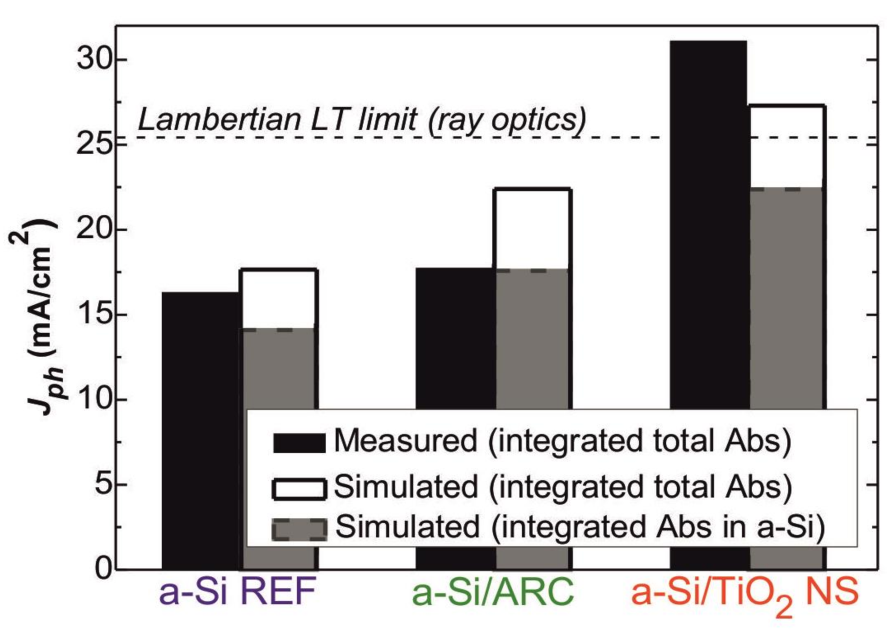
C) *RF magnetron Sputtering:* infiltration of the high index TiO_2 material

D) *Lift-off:* removal of the spheroids sonication in a Toluene Bath

Optical Measurements and simulations



Photocurrent and Efficiency Enhancement



Conclusions

We developed a colloidal lithography (CL) methodology to fabricate TiO_2-based light trapping structures, with sizes within the wave-optical regime, to be applied on the front surface of thin film solar cells. Such nanostructured antireflection coatings provide the cells with an optical enhancement estimated to yield a promising increment of 58.7% and 27.3% (relative to an unpatterned a-Si:H cell and a cell patterned with an ARC, respectively) in the photocurrent density supplied by the cell.

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