Spectrally-selective photonic crystal-CQD coatings

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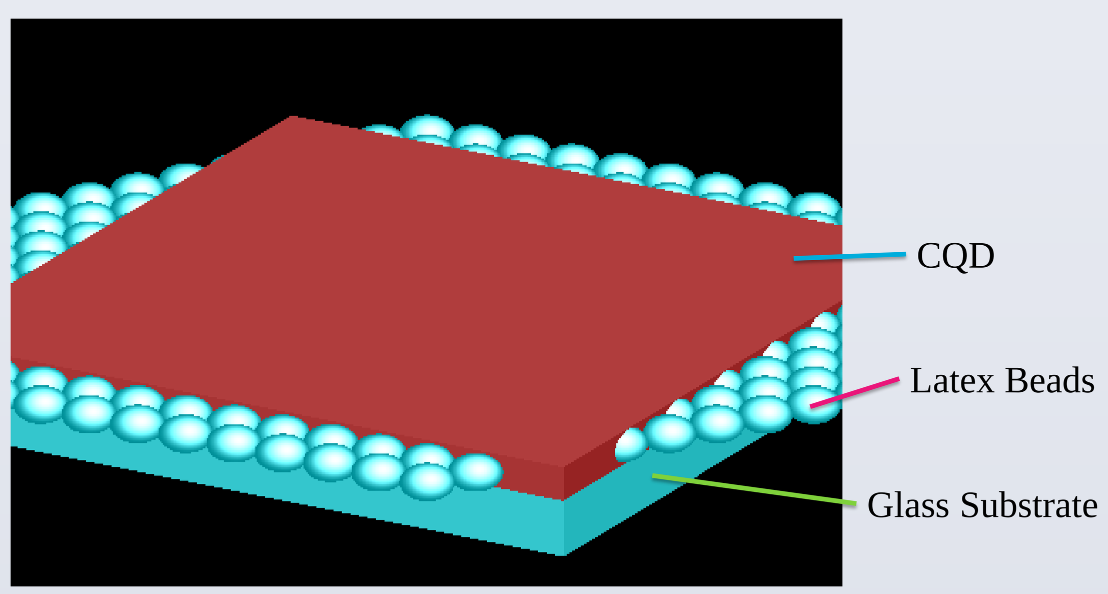
Introduction

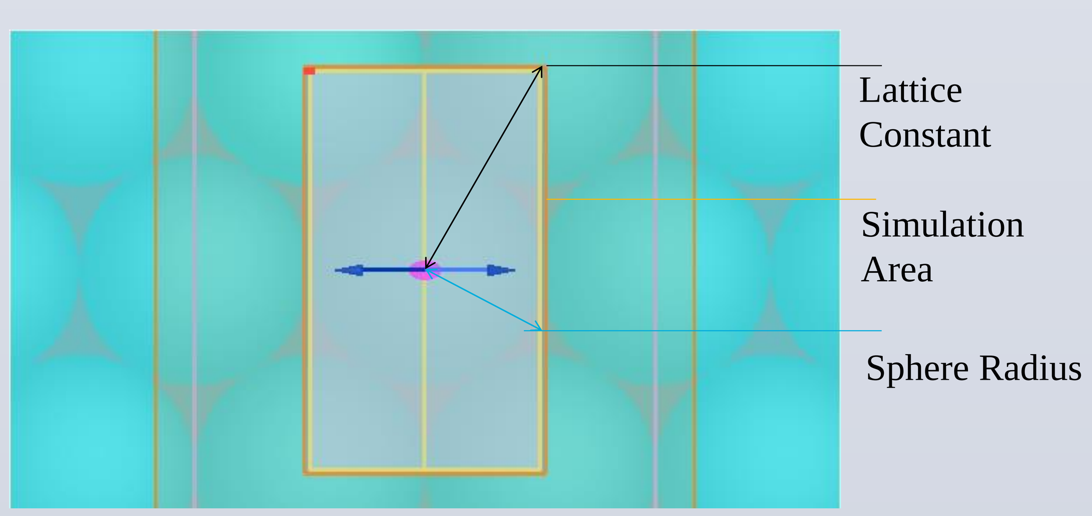
- Growing Global Power Demands (20 TW)
- Potential for Solar Power (174,000 TW)
- Colloidal Quantum Dot (CQD) Solar Cells
- Spectrally-Selective Devices ***via*** Photonic Crystals (PCs)
- Goal is to employ PC lattices to induce transparency in the visible portion of the spectrum
- Applications in multijunction solar cell devices

Design



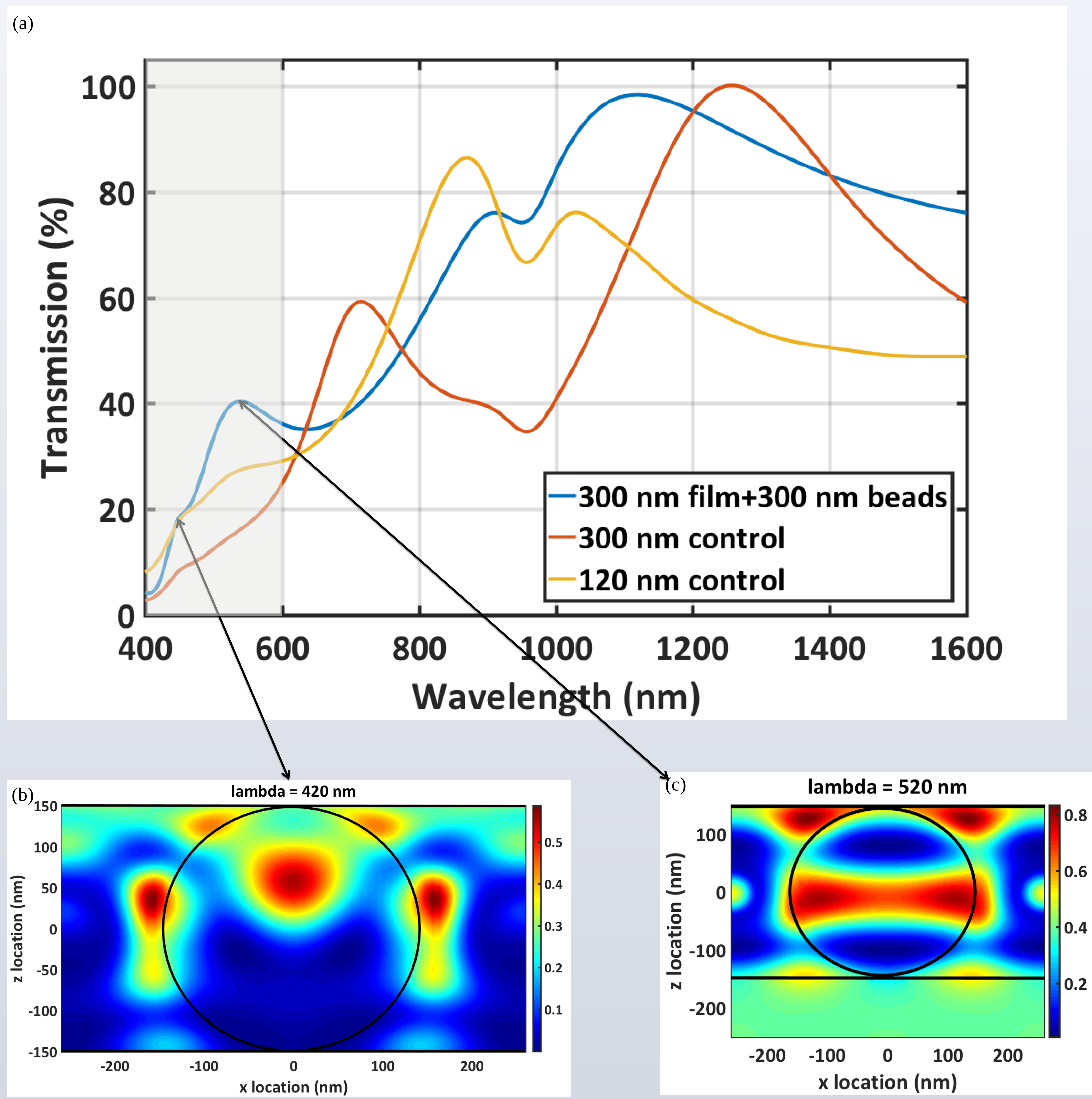
Spherical Setup

This design used spherical nanostructures made of latex (n = 1.59) embedded in a 300 nm thick CQD film with 300 nm hexagonal lattices above a glass substrate.



A unit lattice cell with periodic boundary conditions is simulated to optimize computing resources

Experiments



Figures

- Figure (a) – Transmission spectra for photonic crystal embedded structure and control films
- Figure (b) – Latex sphere electromagnetic spatial field profile at 420 nm
- Figure (c) – Latex sphere electromagnetic spatial field profile at 520 nm

Results

- Control films possess relatively low transmittance in the visible portion of the spectrum (from ~400 nm to ~600 nm)
- The film with the photonic crystals shows an induced higher transparency over this relevant wavelength range
- The electromagnetic field profile in Figure (b) shows an intense localization of the field outside the photonic crystals and in the absorbing medium.
- The electromagnetic field profile in Figure (c) shows an intense localization of the field inside the photonic crystals.
- These field profiles illustrate the enhancement of the transmission spectrum. The transmission peak at ~ 520 nm is as a result of guided modes through the spheres.

Conclusion and Outlook

The effect of the photonic crystal lattice can be observed in the transmission spectra comparing the embedded film to the control films.

We are able to induce a higher transmission in the visible wavelength range (400 nm to 650 nm) by means of these embedded nanostructured beads.

From the results, the photonic crystals have proven to be an effective and low-cost technique in tuning spectral profiles for tandem solar cell applications.

Future work includes optimizing and controlling the observed transmission resonance peak across desirable wavelength ranges

References

1. Joannopoulos, John D., Steven G. Johnson, Joshua N. Winn, and Robert D. Meade. *Photonic crystals: molding the flow of light*. Princeton university press, 2011.
2. Adachi, Michael M., André J. Labelle, Susanna M. Thon, Xinzheng Lan, Sjoerd Hoogland, and Edward H. Sargent. "Broadband solar absorption enhancement via periodic nanostructuring of electrodes." *Scientific reports* 3 (2013): 2928.