Scattering from ZnO Nanorods in Absorbing Perovskite Layer

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Introduction: High efficiency at low cost makes perovskite ($CH_3NH_3PbI_3$) solar cells attractive. ZnO nanorods can be a good replacement of mesoporous TiO_2 which is commonly used as electron transport layer because of their higher electron mobility. Scattering from ZnO nanorods have been optimized here.

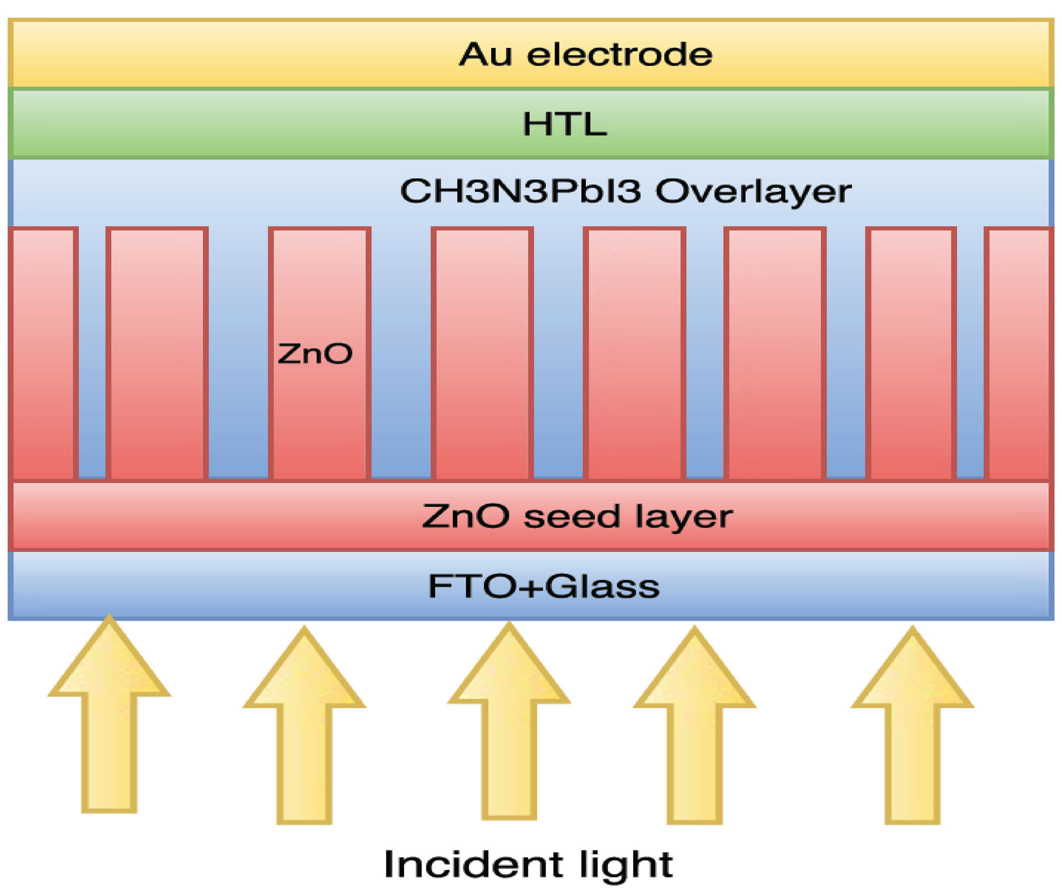

Figure 1. Schematic of perovskite ZnO nanorod solar cell

Computational Methods: To study the effect of change in electric field due to ZnO nanorods independent from the absorption in the perovskite Maxwell equation was solved to find Electromagnetic field excited by an active port in a cuboid surrounded by Cartesian PML layer. The resultant field was then used as background field to solve for scattered field.

$$\nabla \times \mu_r^{-1}\left(\nabla \times \vec{E}\right) - k_0^{\,2}\left(\varepsilon_r - \frac{j\sigma}{\omega\varepsilon_0}\right)\vec{E} = 0$$

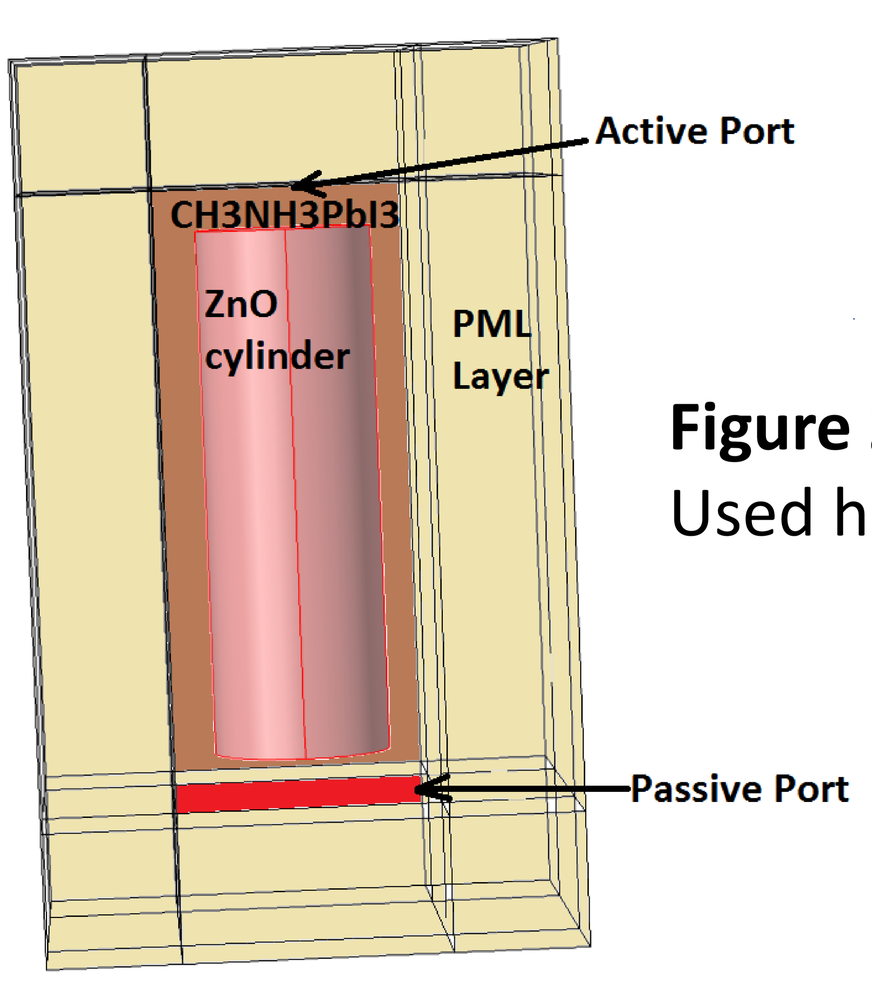

Figure 2. Simulation setup Used here.

Far field in absorbing medium will be distance dependent hence poynting integrated at the surface and were divided by the average value of incident power at the cylinder to find scattering cross-section.

$$W_{sca} = \quad [\vec{\boldsymbol{E}}_{sca} \times \vec{\boldsymbol{H}}_{sca}] \cdot \boldsymbol{n}ds$$

Results: The values of scattering per unit volume suggest that there will be an improvement in the path length of light in the device. The time averaged electrical density is greater in the perovskite compared to the ZnO nanorod which will facilitate charge carrier generation in the device.

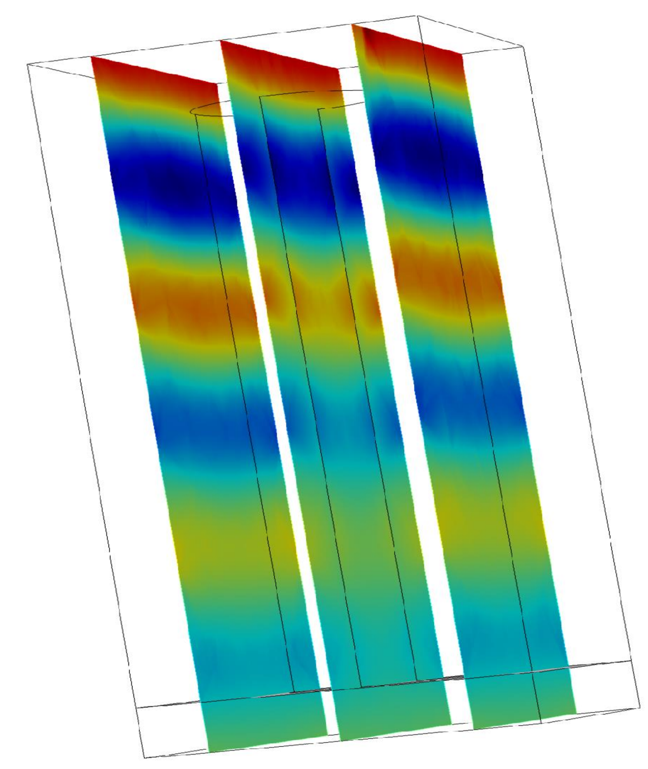

Figure 3. Total electric field y Component

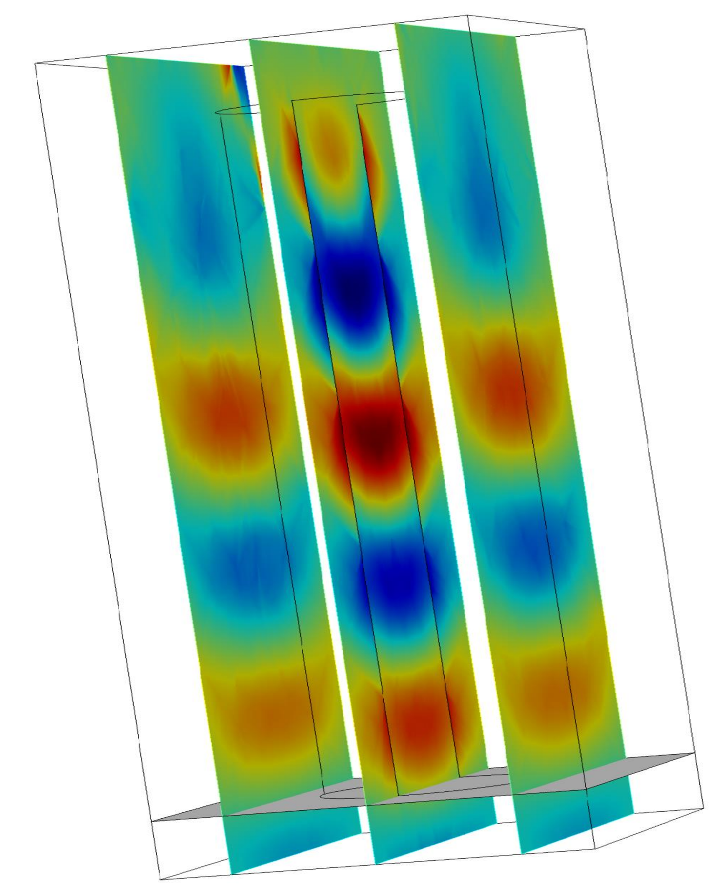

Figure 4. Relative electric field y component

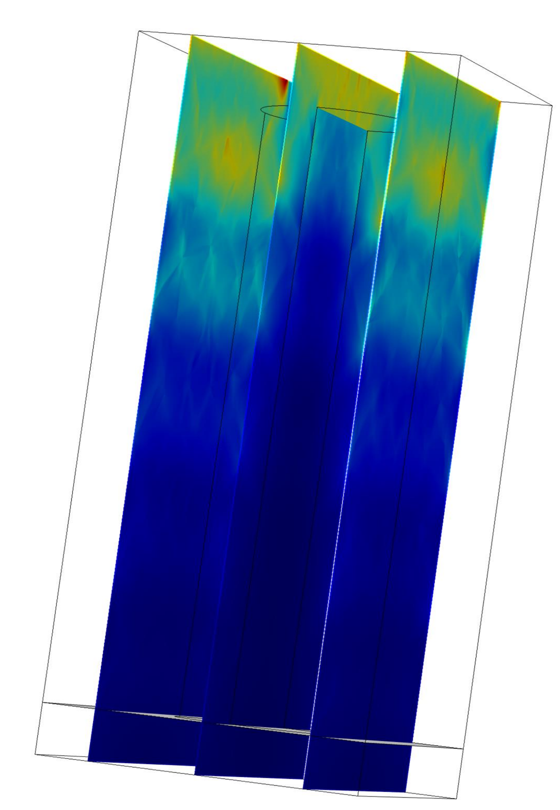

Figure 5. Time-averaged electrical density

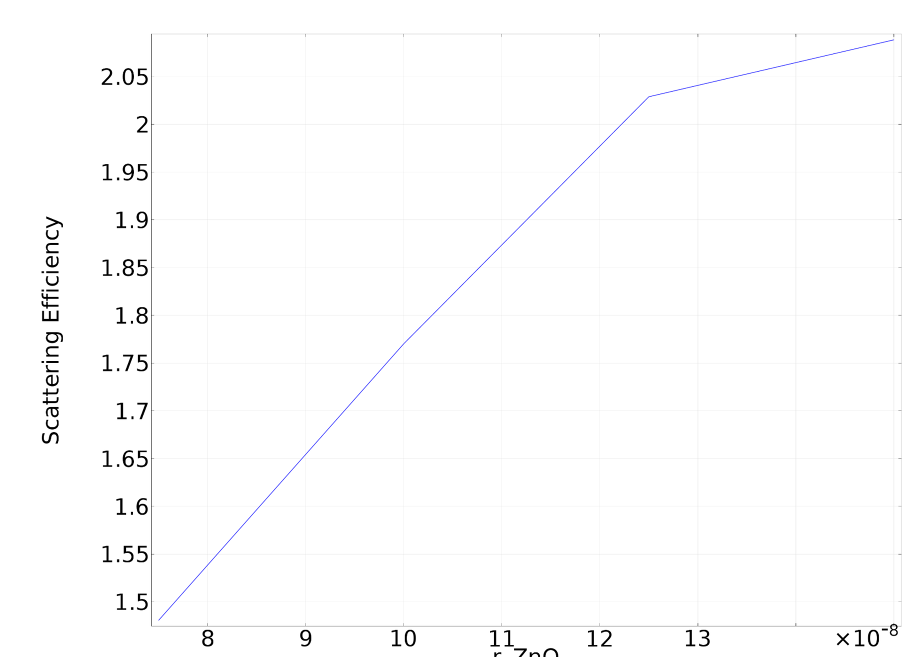

Figure 5. Scattering coefficient

Conclusions: There is an increase in the scattering per unit volume with increase in radius of the nanorods, with rate of increase decreases with increase in radius. However the electron transport will be adversely affected by increasing the diameter of nanorods hence full device simulation will be needed to optimize the diameter of nanorods.

References:

1. M. Grätzel, Nat. Mater., 2014, 13, 838–842.
2. T. G. Deepak, G. S. Anjusree, S. Thomas, T. A. Arun, S. V. Nair and A. Sreekumaran Nair, RSC Adv., 2014, 4, 17615.
3. R. Ruppin, Opt. Commun., 2002, 211, 335–340.
4. C.-W. Chen, S.-Y. Hsiao, C.-Y. Chen, H.-W. Kang, Z.-Y. Huang and H.-W. Lin, J. Mater. Chem. A, 2014, 3, 9152–9159