Light guiding—moving beyond fossil fuels with next generation luminescent solar concentrators

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Despite receiving the highest average annual solar insolation, Australia's current use of solar energy accounts for only 2.4% of the country's electricity generation [1]. The greatest share still comes from fossil fuels. Although the cost of electricity from solar cells has dropped by 72% since 2009 [1], the high production cost of solar panels remains a major hurdle for the transition to renewable energy. To compete with coal, alternative approaches are needed.

Motivated by its potential to lower the cost of solar energy conversion, we report here on reducing the required area of solar cells using Luminescent Solar Concentrators (LSC). An LSC is a thin film of semi-transparent material with dyes or nanoparticles embedded inside. The dye can absorb light and redirect it to the sides of the film where a narrow solar cell is attached. This allows a relatively small set of solar cells to collect a large area of sunlight.

The emergence of new luminescent materials such as semiconductor nanocrystals and inorganic upconverters has renewed interest in LSCs. Using Monte Carlo ray-trace modelling, device performance using such luminescent materials are explored with consideration of host matrix properties. The waveguide refractive index, Stokes shift and film geometry are optimised to maximise the efficiency of an LSC. The different boundary conditions for the light including air gaps and multiple layers are also explored. The relationship between the dye and the film structure will provide guidance in designing a more efficient concentrator and, ultimately, a better solar cell device.

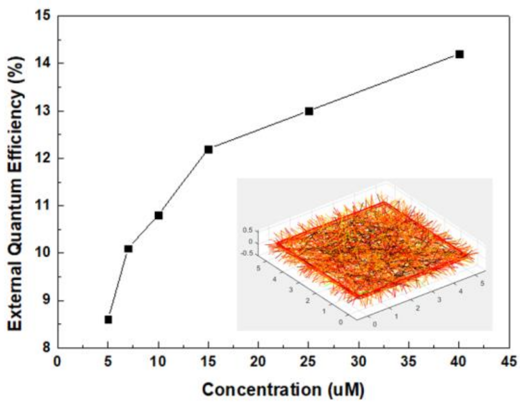

Figure 1. The simulated external quantum efficiency of LSCs under excitation (516nm) as a function of concentration of Lumogen Red 305. 10,000 photons were traced in each simulation. The insert illustrates one Monte-Carlo ray simulation of LSC at G=5.

[1] Ball, A., *Australian Energy Update*, I.a.S. Department of Industry, Editor. 2016, Australian Energy Statistics Canberra.

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