



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE



Self-tracking solar concentration

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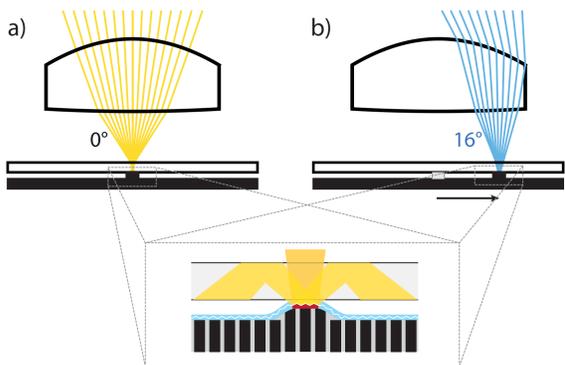
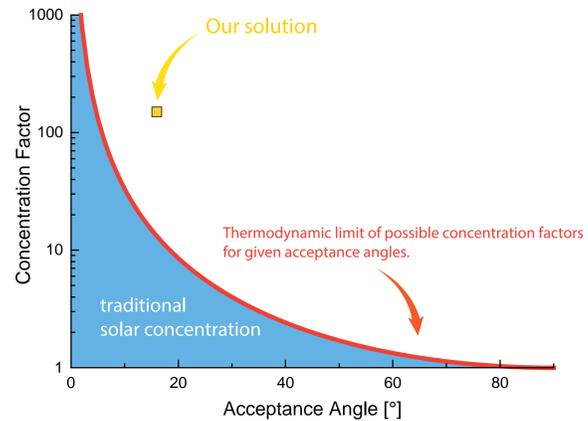
Materials Science & Technology



Principle

Solar concentration allows the cost-efficient use of expensive solar cells by a reduction of needed solar cell material and using optics to keep the same input aperture. There is a tradeoff and limit between the acceptance angle of a solar concentrator and its maximum concentration factor. Our proposed self-tracking concentrator exceed this limit by self-aligning towards the sun and is able to achieve concentration ratios of 150x with an acceptance angle of $\pm 16^\circ$. In addition concentrated sunlight on solar cells can be used to improve the efficiency and voltage of a solar cell.

The SHINE project makes use of these facts to meet the 1.8V it needs to produce Hydrogen.

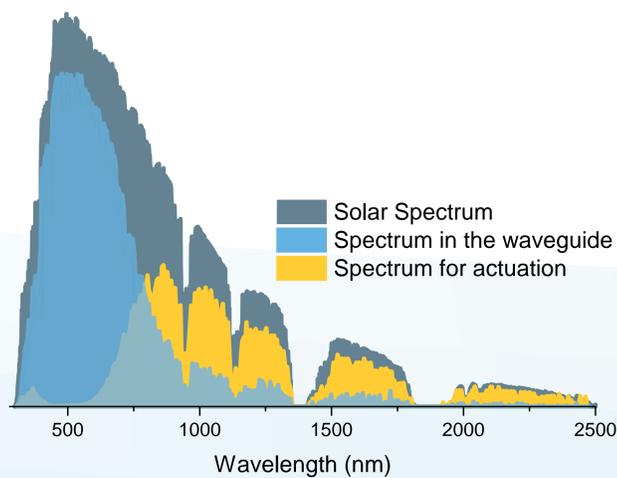


The self-tracking concentrator works for angles of $\pm 16^\circ$ (case a and b). As can be seen in the inset to the left, incoming sunlight is split into a transmitted infrared part (red) and a reflected visible part (bright yellow) by a dichroic line prism array (light blue). The infrared light heats up a paraffin wax/carbon black mixture (black), which creates a coupling feature at the waveguide (grey) due to thermal expansion. The expanded actuator presses the membrane against the waveguide allowing short wavelength light (bright yellow) to be coupled into the waveguide.

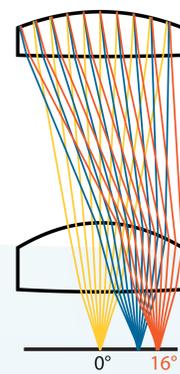
Elements



Paraffin wax is mixed with carbon black (a) and filled into the honeycomb hole array (b) in order to create the actuator. PDMS is spincoated on top to create a flexible membrane and the actuator is sealed on the back with a glass slide (c). d) Top view onto the steel actuator (bright) filled with paraffin wax/carbon black

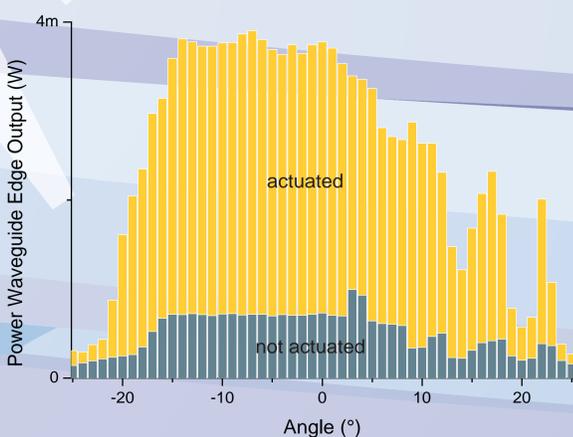


The dichroic prism membrane separates the spectrum around 750 nm. The IR light above is transmitted through the membrane whereas the visible light is reflected at a sufficient angle to be coupled into the waveguide.



The optical system uses two off-the-shelf aspheric lenses to create a flat Petzval field curvature over $\pm 16^\circ$ incoming angle. This allows for a continuous actuation effect of the paraffin actuator and constant coupling efficiencies.

Results & Future



The actuator allows for actuation from -16° to $+16^\circ$ due to the optical system. The coupled power drastically decreases for angles above 16° . The blue curve shows the minimum amount of sunlight for every angle whereas the yellow curve shows the maximum amount of power coupled.



The SHINE project is developing a demonstrator as shown above. It will be the first step towards the final version and features 20x concentration with $\pm 16^\circ$ acceptance angle.