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Self-tracking solar concentration

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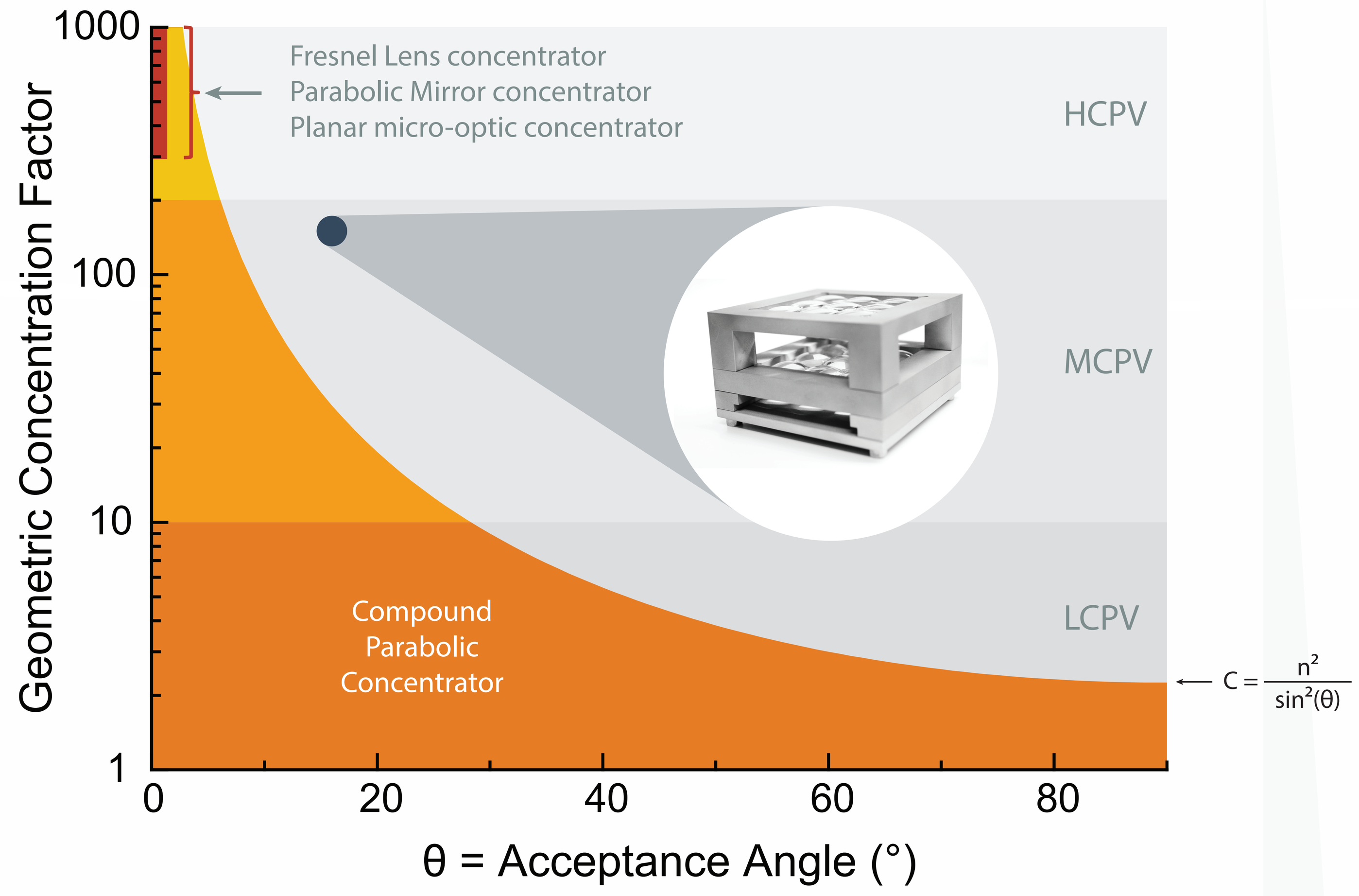
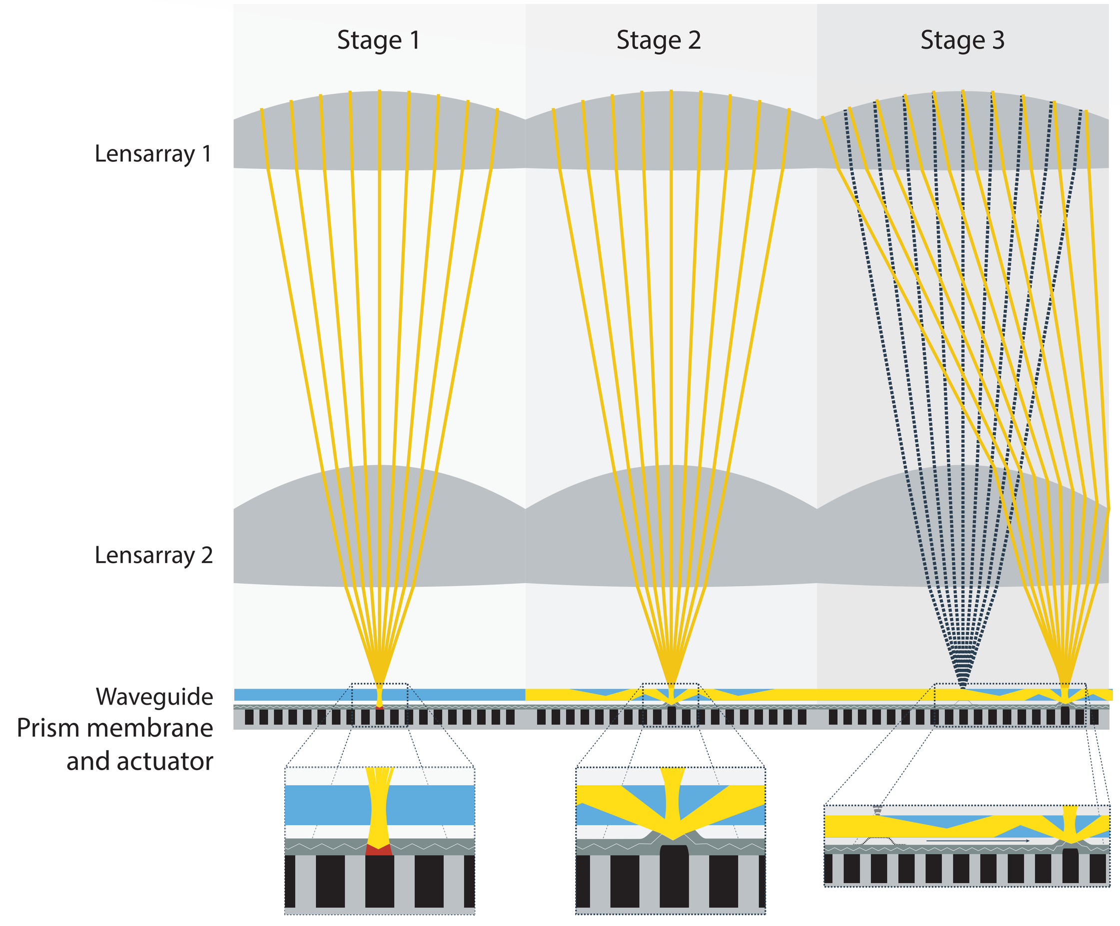
Principle

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 ±16°. In addition concentrated sunlight can be used to improve the efficiency and voltage of a solar cell.

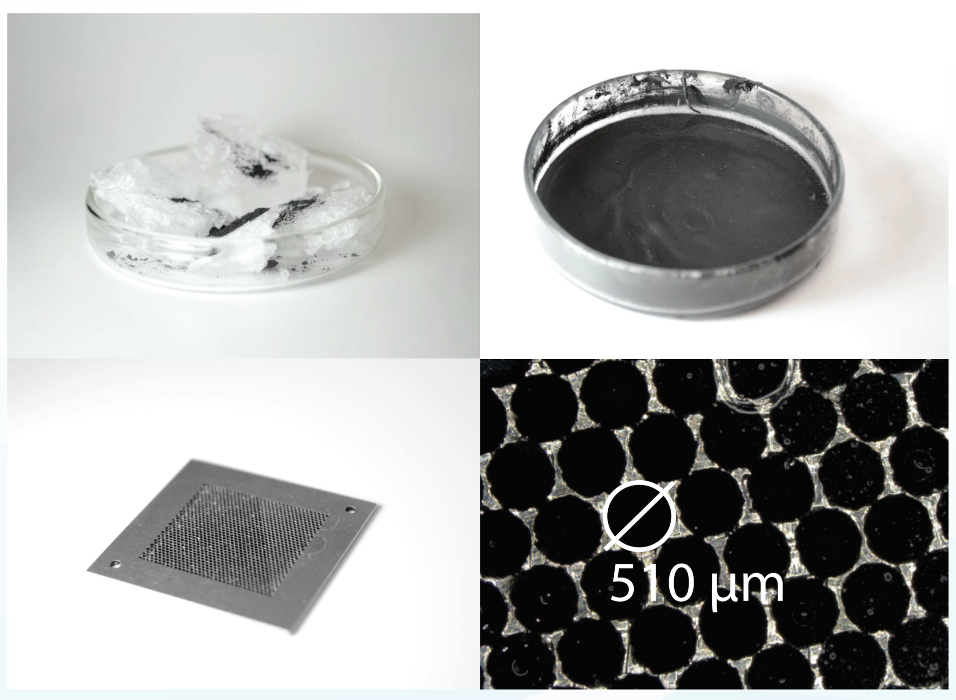




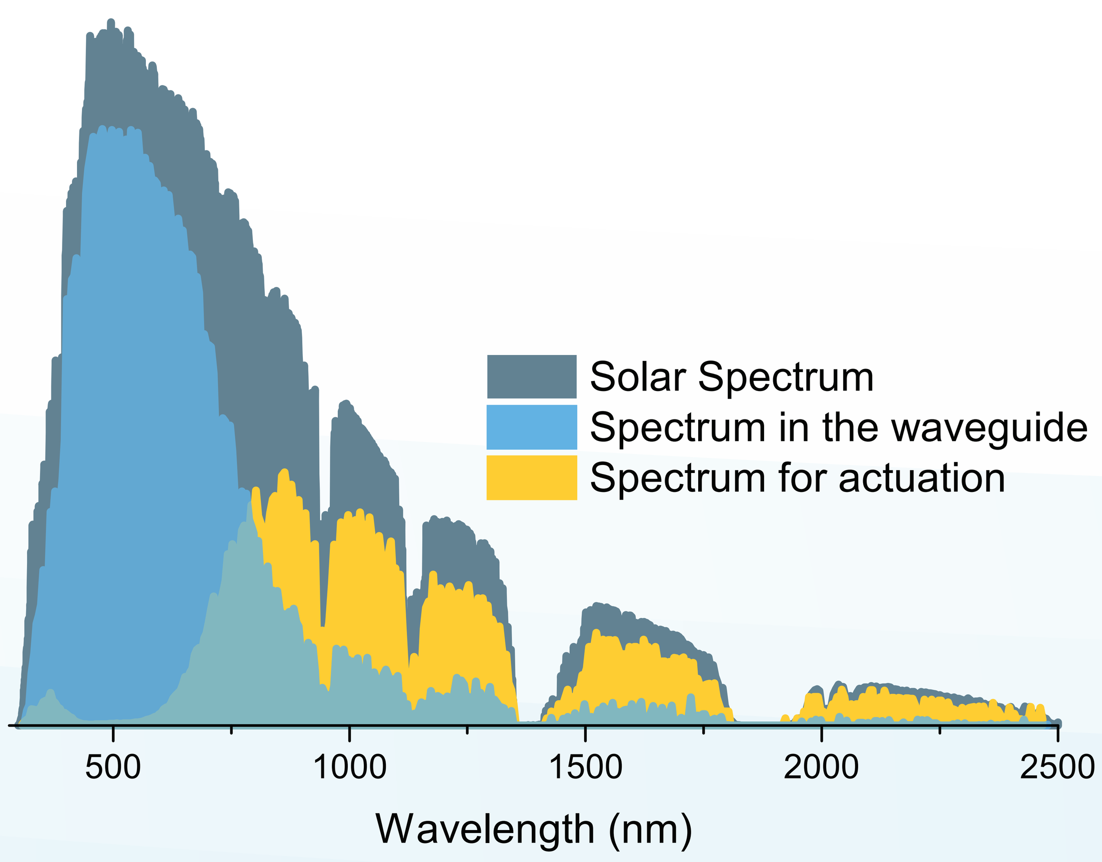
The self-tracking concentrator works for angles of ±16°. As can be seen in the image to the left, incoming sunlight is split into a transmitted infrared part (red) and a reflected visible part (bright yellow) by a dichroic line prism array (light blue). The infrared light heats up a paraffin wax/carbon 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

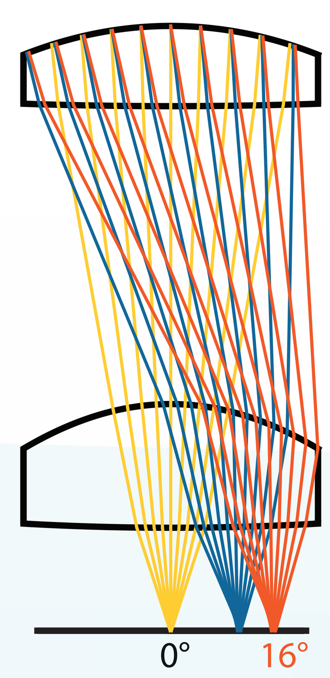
Photovoltaic Components



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.

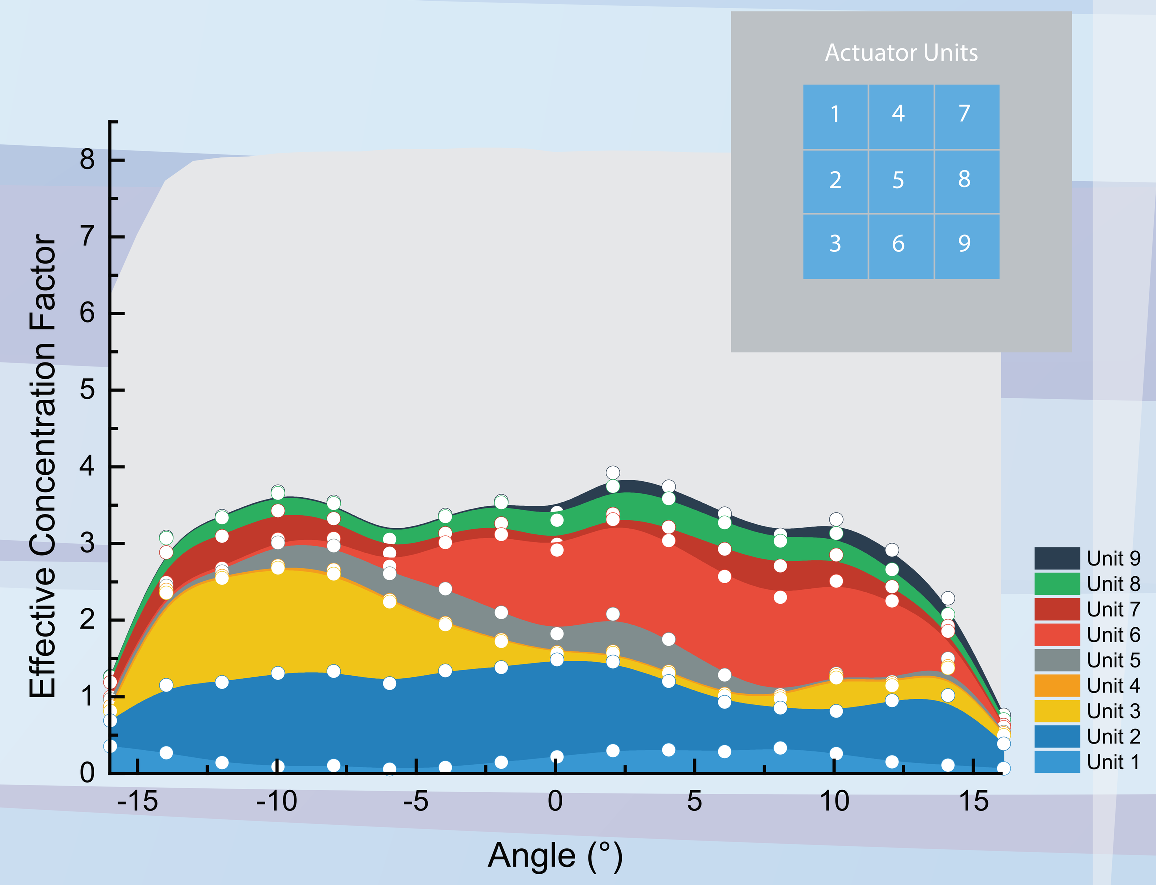


The optical system uses two off-the-shelf aspheric lenses to create a flat Petzval field curvature over ±16° incoming angle. This allows for a continous actuation effect of the paraffin actuator and constant coupling efficiencies

Results & Future

The SHINE project is delopping a demonstrator as shown above. It is a step towards the final version and features a >40 cm^2 waveguide with ±16° acceptance angle.

Under the current device configuration the maximum theoretical concentration is 8X. Different units within the concentrator work indepently and add to the overall performance of the device. The experimental SHINE device demonstrated concentration levels approaching 4X.



Volker Zagolla, Eric Tremblay, and Christophe Moser. Proof of principle demonstration of a self-tracking concentrator. Optics Express, Vol. 22, Issue S2, pp. A498-A510, 2014

Volker Zagolla, Didier Domine, Eric Tremblay, Christophe Moser. Self-tracking solar concentrator with an acceptance angle of 32°. Optics Express, Vol. 22, Issue S7, pp. A1880-A1894 (2014)