

BEAM STEERING LENS ARRAY FOR SOLAR COOKING

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Abstract: Operation of concentrator based solar cookers is complicated by the need to accurately rotate the large parabolic mirror for solar tracking. Here we demonstrate a workaround. Via beam steering lens arrays, we can track sunlight with a simulated >70% efficiency across $\pm 35^\circ$ tracking range, using millimeter-scale lateral translation. This eliminates the need to rotate the mirror, facilitating the design of a simpler cooker. Full-day cooking can be achieved by manually reorienting the cooker 1-2 times a day in the general direction of the sun, while accurate automated tracking is performed by small low-cost actuators. Additional features such as adjustable power level can also be implemented.

The optical system was simulated and optimized using Zemax OpticStudio, and a functional 1:15 scale prototype has been constructed. The prototype demonstrates a promising total optical efficiency of $\approx 25\%$ (beam steering lens array efficiency $\approx 60\%$, reflector efficiency $\approx 50\%$, focusing error efficiency: $\approx 80\%$). Total optical efficiency is expected to increase to 50%-60% using improved manufacturing methods. The lens array is expected to be compatible with injection molding, enabling low-cost high-volume production. By enabling low-cost automatic tracking, this technology may facilitate inexpensive, maintainable and user-friendly solar cooking, fostering its increased adoption across the world.



Figure 3: Functional small prototype with automatic tracking.

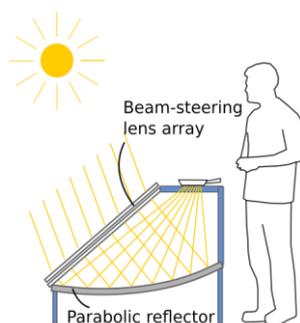


Figure 2: Sketch of solar cooking concept using beam steering.

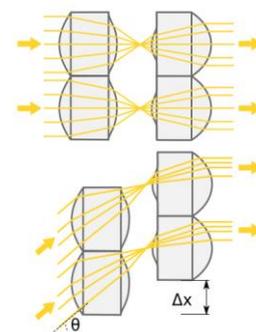


Figure 1: Illustration of how lateral translation of a lens array Δx can redirect sunlight arriving at an angle θ .

Keywords: Solar cooking, Beam steering, Automated tracking, Lateral translation