Docket #: S10-263

Graded Index Lens as a Nontracking Solar Concentrator (AGILE)

Stanford researchers have developed a novel, non-tracking and low cost solar concentrator - Axially Graded Index LEns: AGILE - that has potential to change the economy of the solar cell industry. The AGILE concentrator enables cost-effective, utility-scale, photovoltaic (PV) installations by simplifying the solar tracking, design, construction, installation and most importantly; the maintenance of high-concentration (~1,000 suns) concentrated solar PV systems. The basic, completely passive AGILEs that the lab simulated and demonstrated in the exploratory phase of this research give a concentration of several suns. In high concentration systems, this translates into reduced requirements on design, optical components, construction quality, pointing accuracy and long-term stability. Over the life time of the PV installations, this leads to substantial cost savings and allows the facility to operate at maximum efficiency even under sub-optimal conditions. Applications for AGILE include residential passive panel and large scale utility installations. In addition to solar concentration, the AGILE's unique imaging properties also have potential applications in illumination, optical couplers, displays, anti-reflection coatings, photography and communications.

Figure 1: An AGILE that is linearly graded from RI=1 to RI=3.5 (a) concentrates light perfectly even at very acute angles.
In contrast, cones that are empty (b) or that are homogenously filled with high index (c) reject a
substantial amount of the incident light even at modest incidence angles.

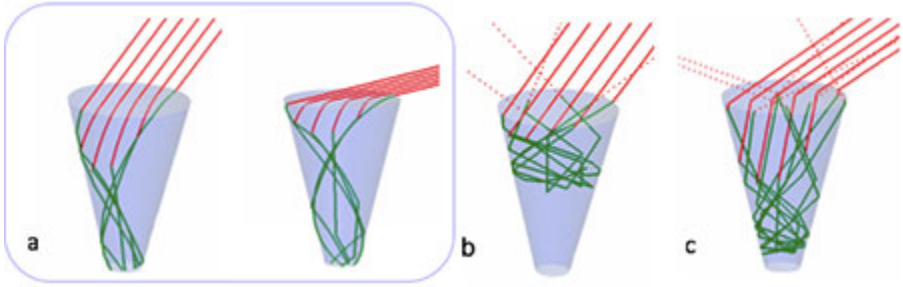
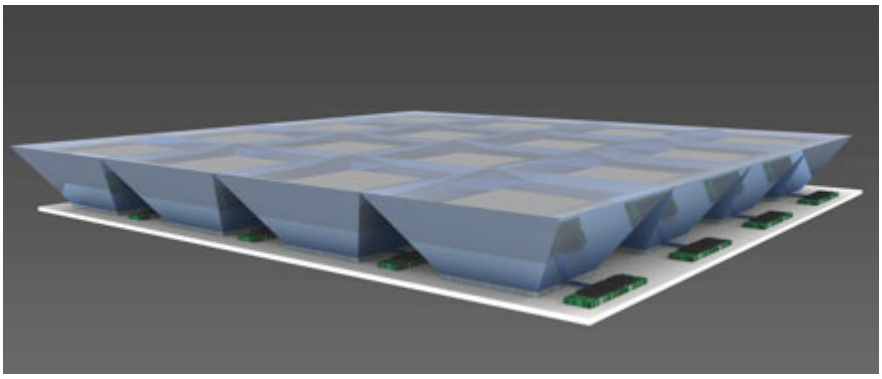


Figure 2: AGILE array passive roof-top system:



Stage of Research: Proof-of-concept
- The basic AGILEs that have been simulated and fabricated/demonstrated give a completely passive concentration of several suns. Low cost and tile-able AGILE arrays have been made using available optical polymers and 3D printing that give up to 10 Suns of passive concentration and across the solar spectrum.
- The simulations also show that the AGILE can achieve a concentration of 100 suns with an acceptance angle as large as 30 degrees.

On-going Research:
- Designing low-cost manufacturing processes for arrays of AGILEs to enable large-scale implementation.

Applications

- **Solar Energy:**
  - High efficiency flat panels for residential installations.
  - Robust, easy to maintain, large scale PV installations that may operate in hybrid fashion, e.g. by combining PVs with solar thermal and/or solar thermo-emission.
- AGILE's unique optical coupling properties also have potential applications in **Illumination, Displays, Anti-reflection coatings, Photography, and Communications**

Advantages

- Low cost with simple installation and encapsulation

- Does not need to track the sun
- Operation in diffuse light conditions
- High conversion efficiency
- Does not require substantial real estate
- Potential for large scale implementation and hence potential for high impact on reducing greenhouse gas emissions
- Takes advantage of the fact that the density of electromagnetic radiation modes is proportional to the square of the Refractive Index to create non-tracking solar concentrators

Publications

- Vaidya, N., & Solgaard, O. (2022). Immersion graded index optics: theory, design, and prototypes.*Microsystems & nanoengineering*, 8(69), 1-12.
- N. Vaidya, R. Dauskardt, and O. Solgaard, "AGILE: Axially Graded Index LEns as a non-tracking solar concentrator," Renewable Energy and the Environment, OSA Technical Digest (CD) (Optical Society of America, 2011), paper JWD2.
- Brown, Ed. Focusing the Sun – A Big Gain for Solar Power Efficiency, *Tech Briefs,* August 2022

Patents

- Published Application: 20120113637
- Issued: 9,329,308 (USA)

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