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Breakthroughs in Solar-Powered Lasers

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Solar-powered laser systems directly convert free broadband and incoherent solar radiation into narrowband and coherent laser radiation through an active medium, being considered as one of the most promising technologies in renewable energy research.
Our research group, led by Prof. Dr. Dawei Liang, was established more than a decade ago with the aim of substantially improving the performance of solar-powered lasers. Currently, we have been seeking high solar laser performance through the development of alternative prototypes for pumping laser crystals with broader absorption spectrum in the visible region (Ce:Nd:YAG), whose outcomes will be addressed in this invited talk, and which resulted in the following breakthroughs:

- The side-pumping of a Ce:Nd:YAG laser rod at NOVA solar facility led to 1.6 times increase in solar laser collection and conversion efficiencies compared to that with Nd:YAG laser rod under the same pumping conditions This work demonstrated the great potential of the Ce:Nd:YAG laser material as a gain medium for solar-pumped lasers, being featured in Journal of Photonics for Energy.
- Maximum continuous wave solar laser power of 40 W was registered by adopting a side-pumping configuration with a rectangular light guide, being the highest laser power level reported from a solar powered Ce:Nd:YAG laser medium.
- Records in collection, slope, and solar-to-laser conversion efficiencies of 41.3 W/m^2, 7.64%, and 4.64%, respectively, were recently attained by end-side-pumping three thin Ce:Nd:YAG laser media simultaneously within a common pump cavity. This system allowed the concentrated solar radiation to be shared by the three laser rods, ensuring not only a substantial alleviation of the thermal lensing effects but also a significant rise in solar laser efficiency. This breakthrough was spotlighted in Laser Focus World.
- The lowest threshold pump power of 29.2 W was obtained with the first Ce:Nd:YAG solar laser pumped under a cloudy sky. The cloud-filtered sunlight enabled notable improvements in the solar laser efficiency by lessening the thermal lensing effects.

In addition to the abovementioned breakthroughs, innovative solar laser schemes were also both numerically and experimentally performed for high stable solar laser emission with enhanced efficiency, thermal performance, and tracking error compensation capacity. Through experimental work, large enhancement in solar laser tracking error compensation capacity was confirmed for the first time with a dual-rod side-pumping scheme.
Since this technology can be operated using only renewable energy, it may bring an important economic advantage for countries with high solar availability and for the future development of sustainable industrialization, either on Earth or in Space.

Authors: TIBÚRCIO, Bruno; LIANG, Dawei; GARCIA, Dário; COSTA, Hugo; ALMEIDA, Joana (Centro de Física e Investigação Tecnológica (CEFITEC), Departamento de Física, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal); CATELA, Miguel; VISTAS, Tibúrcio

Presenter: ALMEIDA, Joana (Centro de Física e Investigação Tecnológica (CEFITEC), Departamento de Física, Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa, 2829-516 Caparica, Portugal)

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