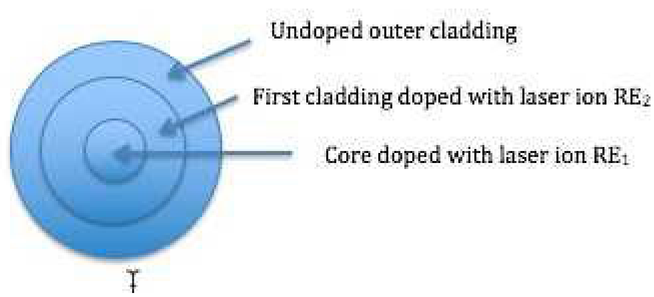
Docket #: S18-285

Compact, Self-Cooling, Rare-Earth Doped Fiber Laser

Stanford researchers leveraged anti-Stokes fluorescence cooling to design a compact, self-cooling fiber laser. Rare-earth (erbium, ytterbium, etc.) doped optical fibers are attractive optical gain providing devices (i.e. fiber lasers and fiber amplifiers), but power output is limited due to internal heat generation, which requires active cooling often in the form of bulky heat sinks, messy water-based coolers, and expensive temperature controllers. To eliminate bulk and increase performance, the Digonnet Group at Stanford tailors the fiber core and cladding doping to create a laser core, and a cooling cladding layer. The core pump creates gain at the lasing wavelength in the core, while the cladding-pump source creates anti-Stokes fluorescence cooling in the cladding ions. The cladding diameter and doping is determined by how much cooling is required to offset core heat generation. To maintain optimal temperature along the fiber, the cladding diameter can vary along the length. This method creates an even temperature distribution without sacrificing laser efficiency.



Cross section of ASF cooled optical fiber – The fiber to be cooled is doped with laser ion RE_1. Anti-Stokes fluorescence cooling goes on in the cladding doped with laser ion RE_2. Due to refractive index differences the core and first cladding are optical waveguides. In order to maintain uniform cooling, doping concentration and cladding diameter can vary along the length of the cladding. The fiber can also be coiled to homogenize temperature differences.

Applications

- Optical fiber lasers and amplifiers

Advantages

- Compact, vibrationless, and lower cost - free from bulky heat sinks, messy water-based coolers, and expensive temperature controllers.
- Stable performance with increased output power - uniform temperature distribution without sacrificing laser efficiency.

Publications

- Knall, Jennifer Maria, Mina Esmaeelpour, and Michel JF Digonnet. "Model of Anti-Stokes fluorescence cooling in a single-mode optical fiber." *Journal of Lightwave Technology* (2018).
- "Stanford researchers develop first self-cooling laser made with a silica fiber" Stanford News, March 2021

Patents

- Published Application: 20200059063
- Issued: 10,790,633 (USA)

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