High-Energy, Short Pulse, Tunable Laser Gain Media

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BACKGROUND

The past decade has seen significant advances in the development of high-energy laser (HEL) technologies, with improvements in pumping technology, cavity design, cooling methods, and gain media quality. The search for gain media with superior optical, thermal, and mechanical properties remains intense because improvements in the material properties translate directly to increases in device performance. Advanced laser gain materials that provide access to wavelength tunability, short pulses, and so on have paved the way for the study of light-matter interactions, break-through medical applications, and imaging/spectroscopy.

Traditionally accepted design paradigms dictate that only optically isotropic (cubic) crystal structures with high equilibrium solubility of optically active ions are suitable for polycrystalline laser gain media. The restriction of symmetry is due to light scattering caused by randomly oriented anisotropic crystals, while the solubility problem arises from the need for sufficient active dopants in the media. These criteria limit material choices and exclude materials that have superior thermo-mechanical properties than the state-of-the-art laser materials. Alumina (Al_2O_3) is an ideal example; it has a higher fracture strength and thermal conductivity than today’s gain materials, which could lead to revolutionary laser performance. However, alumina has uniaxial optical proprieties and the solubility of rare earths (REs) is two-to-three orders of magnitude lower than dopant concentrations in typical RE-based gain media.

TECHNOLOGY DESCRIPTION

Researchers at UC San Diego have invented new strategies to overcome the above limitations with demonstrated gain in a RE-doped alumina (Nd:Al_2O_3) for the first time. The key insight relies on tailoring the crystallite size to other important length scales—wavelength of light and interatomic dopant distances, which minimize optical losses and allow successful Nd doping. The result is a laser gain medium with a thermo-mechanical figure of merit of R_S~19,500Wm^{-1}, a 24 and 19,500 fold improvement over the high-energy-laser leaders Nd:YAG (R_S~800Wm^{-1}) and Nd:Glass (R_S~1Wm^{-1}). Moreover, the emission bandwidth of Nd:Al_2O_3 is broad, ~13THz,. The successful demonstration of gain and high bandwidth in a media with superior Rs can lead to development of lasers with previously unobtainable high-peak powers, short-pulses, tunability, and high-duty-cycles.

APPLICATIONS

This technology will find application in high energy lasers, tunable lasers and pulsed lasers for a variety of industries including defense, healthcare and communications.

ADVANTAGES

The thermo-mechanical properties of the laser gain medium described herein exceed all other known gain medium produced to date, and accommodates a broad 13 THz bandwidth

STATE OF DEVELOPMENT

A working prototype has been built and tested.

INTELLECTUAL PROPERTY INFO

Patent pending and available for commercialization.

PATENT STATUS

Patent Pending

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OTHER INFORMATION

KEYWORDS

Transparent ceramics; Gain materials; Current Activated Pressure Assisted Densification (CAPAD); Spark Plasma Sintering, Radiative Lifetime, Emission Cross-Section

CATEGORIZED AS

- Optics and Photonics
  - All Optics and Photonics

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