Hybrid Gain Guiding in Laser Resonators

Advantages
- Novel hybrid scheme uses only a short length of gain guided medium, resulting in reduced thermal issues. Unlike prior art, which requires pumping along the length of the gain medium, proving costly and difficult due to length and thermal issues when high powers are desired
- LMA fibers allow the development of lasers with very high powers, high efficiency, simple construction and compact size, resulting in inexpensive fibers
- Scalable to work with any glass type or dopant ion that can currently be made into fiber, this innovative design proves to be very flexible and easily adopted by current fiber manufactures

Invention
Methods, systems, apparatus and devices for hybrid gain guiding in laser resonators.

Background
Fiber lasers are becoming increasingly popular for a number of applications which had traditionally been the realm of bulk solid state lasers. High power fiber lasers have received great attention because of their ability to provide high wall-plug efficiency and excellent beam quality at high power levels. Fiber laser technology offers several key advantages for generation of high power beams over other industrial lasers. Due to their large surface-to-volume ratio, dissipation of large heat loads is possible without active cooling. Also, uniform thermal loading is possible due to distributed pumping schemes. However, in order to take full advantage of the properties of the gain fiber, the detrimental effects of fiber nonlinearities must be minimized. This can be achieved by using large mode area (LMA) fiber. The LMA ensures a large effective mode area which greatly reduces the nonlinear coefficient. Concurrently, the number of modes guided by the fiber also needs to be minimized to avoid mode coupling noise and ensure excellent beam quality. One approach uses single mode conventional index guided fibers spliced onto multimode fibers, but because standard index guiding LMA fibers are limited to small core sizes, they cannot withstand high output powers. Another approach uses high power non-fiber based lasers like solid state crystal and thin disk, but they have difficulty reaching high powers and high beam qualities. Other LMA concepts and designs such as photonic crystal fibers, and chirally coupled fibers are far more complex and hence challenging and expensive to manufacture.

The present invention introduces a new LMA fiber laser approach called, hybrid gain guiding. Gain guiding is when light propagates only in the optical gain region, increasing the amplification of radiation and reducing the natural tendency of the light to spread out by diffraction. This novel invention combines the best features of gain guiding and fiber into a single hybridized system. This innovative system uses a gain guiding element to reduce or completely remove the number of higher order modes in a multimode laser resonator (laser cavity with multiple modes), creating large low order mode areas in the fiber lasers. LMA fibers allow the development of lasers with very high powers, high efficiency, simple construction and compact size. The benefits of such a hybrid gain guiding scheme are numerous, including reduced thermal issues due to the use of only a short length of gain guiding medium, and easy integration into many different types of solid state lasers. This novel invention is a very attractive approach to high power fiber laser development, and it has wide applications across the laser field.

Application
This novel invention is a very attractive approach to high power fiber laser, which can be used in medical and industrial applications.

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Selected References