Beam cleanup with power scaling in multimode fiber via nonlinear effects

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The multimode fibers, supporting a rich and complex mix of spatial and temporal nonlinear phenomena, have recently reemerged as a viable experimental platform for studying complex physical processes, which has gradually explored the application of optical fibers beyond telecommunications [1, 2]. Among these properties, beam cleanup – a intrinsic characteristic of GRIN fibers occurs during stimulated Raman scattering (SRS) process – has received considerable attention [3, 4]. This feature can be harnessed in the field of laser generation in combination with the acknowledged inherent outstanding characteristics of fibers as active media for lasers, particularly the remarkable beam quality derived from their waveguide structure, which enables the conversion of low-brightness pump laser into high-brightness signal lasers. To achieve this, the pump beam with poor performance on brightness is coupled into the multimode GRIN fiber, propagates along the fiber, and interacts with the material in it, stimulating the emission of laser at a longer wavelength with a Raman shift (the gain for generating a laser is provided by SRS), contributing to high-brightness signal output. This approach combined with the high-power handling capabilities of multimode fibers, paves the way for the development of new laser designs in pure passive fiber-based all-solid-state architecture systems which are more compact and efficient with lower quantum loss, no photon darkening and wavelength flexibility than traditional rare-earth-doped counterparts. These inherent advantages are of great importance for applications in metrology, remote sensing, and medicine.

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