Simulation on thermal load gradient mitigation with auxiliary multi-seeds amplification in fiber amplifier

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Thermal distortions of refractive-index profile as well as other thermally induced degradation mechanisms are increasingly important limitations to power-scaling of diffraction-limited fiber amplifiers [1-3]. While it is in principle possible to take the distortions into account in the design, this is hindered by the strong longitudinal variations of the thermal load. Here we use numerical simulations to investigate multi-tone pumping [4,5] for the equalization of the thermal load along a Yb-doped cladding-pumped fiber amplifier. For this, we use one or more auxiliary pump seeds in to control the energy transfer rate from pump photons to signal photons. The simulations show that the variations in the thermal load can be reduced by an order of magnitude, to a value of 13% of the average thermal load, by the use of two optimized forward-propagating auxiliary seeds.

Figure 1(a) depicts the thermal load along the Yb-doped fiber. It has a core diameter of 6 μm and an inner-cladding /core area ratio of 200. It is pumped by a total pump power of 40 W at 975 nm, with optimized ratios of forward and backward pump power, and with different optimized configurations of forward and backward auxiliary seeds. The variations became 0.0345 W/m. Figure 1(b) shows the power evolution with two forward auxiliary seeds, which we found to be the best configuration of those we report. The pump power ratio, fiber length, auxiliary seed wavelength and power are optimized in Matlab Optimization Toolbox to minimize the variations of the thermal load along the fiber. The signal seed power in simulation is 200 mW.

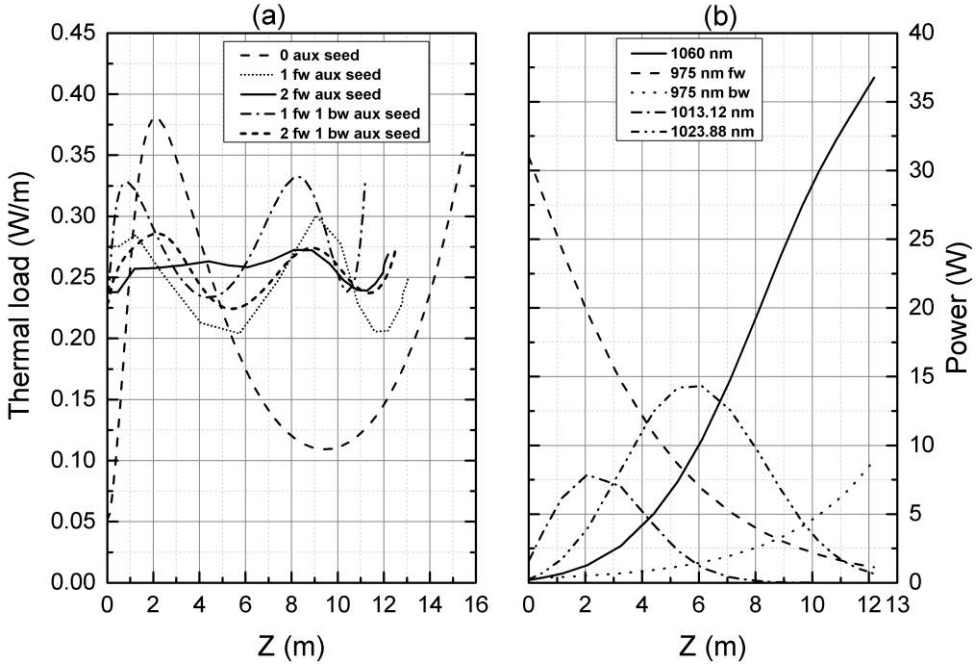

Fig. 1 (a) Thermal load along the fiber in different configurations, aux: auxiliary, fw/bw: forward/backward propagating. (b) Power evolution in 2 fw aux seed configuration.

In addition, the maximum thermal load gradient is reduced by around from 0.3806 W/m to 0.2723 W/m, i.e., by ~30%. This technique can be used in multi-kW amplifiers where the thermal load becomes excessive and where there is a need to pre-compensate for thermal distortions. More results and discussions will be presented on the conference.

References

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