Hybrid Ytterbium-Neodymium Laser Chain and Scalability to Petawatt Peak Powers

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We present here the experimental results of a hybrid ytterbium-neodymium laser chain. A nanosecond, multi-millijoule amplifier based on Yb-doped materials and diode pumping is used as a high energy and high repetition rate seed for a Nd:glass laser chain. Wavelength tunability, choice of Yb-doped material and scalability are also addressed by means of a simulation code.

Several high-energy (>kJ) laser projects in development around the world are evaluating the potential of diode pumping combined with ytterbium-doped materials. In fact, this technology is currently the most energy-effective in delivering Joule level laser pulses at Hz repetition rates [1]. On the other hand, traditional flashlamp-pumped neodymium-doped media are still attractive for obtaining >100 J energies per pulse at an affordable price and with materials that can be grown to large dimensions.

These two approaches have led us to develop a hybrid laser chain that tests the integration of the two technologies addressed. This was achieved by adding two consecutive Yb-doped pre-amplifiers to our chirped-pulse amplification, 10 TW Nd:glass-based laser system operating at 1053 nm. The first regenerative amplifier is based on Yb:glass and delivers mJ-level pulses, which reach the 100 mJ level after a multipass amplifier based on Yb:KYW. The resulting pulses are then seeded into the Nd:glass amplifiers, where their energy is raised to the Joule level.

Given the restriction in the peak operating wavelength of Nd-doped laser media, wavelength tunability in pre-amplifiers is a major issue. We were able to demonstrate operation in the range 1020-1060 nm for the regenerative amplifier at the mJ level. Both this amplifier and the multipass one were carefully designed by using a complete simulation code developed by ourselves which takes into account spectral and energy issues, thermal load and 3D analysis of pump and pulse. The code was successfully benchmarked in the well-known range 1030-1045 nm (Fig. 1), and is also used to study the scalability of this combination.

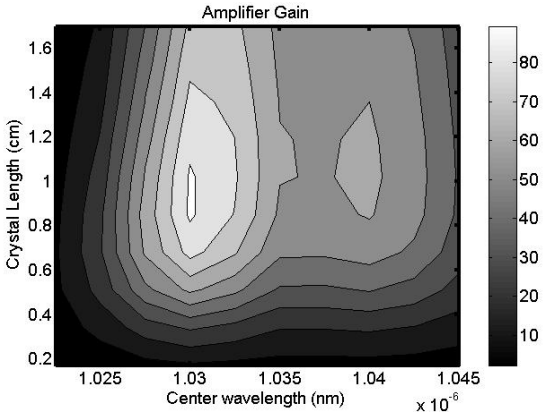

Fig. 1. Multipass KYW amplifier: expected overall gain dependence with seed wavelength and crystal length.

In this work, we present the operation and full characterization of the 100 mJ Yb-based amplifier, seeding a Neodymium 10 TW chain of amplifiers. Based on a simulation code, we also present a study on the scalability of this technique to the Petawatt level.

[1] Siebold, M., Applied Physics B **90** (3-4), 431-437 (2008)

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