THERMAL LENSING IN ND:YAG LASERS: INEVITABLE ABERRATIONS AND CORRECTION POSSIBILITIES

O.V. Kulagin\textsuperscript{1}, I.A. Gorbunov\textsuperscript{1}, A.M. Sergeev\textsuperscript{1}, M. Valley\textsuperscript{2}

\textsuperscript{1}Institute of Applied Physics of the RAS, Nizhny Novgorod, Russia  
\textsuperscript{2}Sandia National Laboratories, Albuquerque, USA

It is well known that thermal aberrations limit the beam quality and power range of high power lasers. According to the traditional approach \cite{1}, the thermal lensing in transversally pumped laser rods causes a parabolic refractive index profile that may be compensated with conventional lenses. However, at a comparatively high power laser pump level we should take into account the thermal dependence of the laser medium physical properties (e.g., thermal conductivity, $dn/dT$, expansion coefficient) and pump inhomogeneity \cite{2}. This more accurate analysis results in a thermal lens with spherical aberrations that induce losses of laser energy and beam quality in high-power lasers.

We review recent experimental efforts to compensate for these thermally induced distortions by using specially designed optical components. In particular, we developed a passively Q-switched Nd:YAG laser with a MOPA configuration based on Brillouin and Raman pulse compression. The laser operates at 100 Hz repetition rate, producing 50 mJ pulses of approximately 30 ps duration at 1530 nm wavelength, with near-diffraction-limited beam quality ($M^2 \leq 1.3$). We used a high power flash-lamp Nd:YAG four-pass laser amplifier at 1319 nm for Raman conversion of radiation in Ba(NO$_3$)$_2$ crystals into the eye-safe range. The effect of spherical aberrations in thermally loaded Nd:YAG rods was examined by calculating the refractive index profile in the laser rods using the measured pump inhomogeneity and the thermal dependence of the physical constants in Nd:YAG. The obtained profile was used for modeling the laser amplification scheme with Zemax software. For efficient aberration compensation an appropriate compensating aspheric element was calculated using Zemax optimization. The required plano-convex aspheric glass plate with a fourth-order parabolic surface profile was manufactured by OJSC "NPO State Institute of Applied Optics" (Kazan). Introducing the aberration compensation into the scheme improved the beam quality ($M^2$ parameter - see figure below) and let us avoid the considerable beam narrowing after the four-pass amplification that occurred in beams without aberration compensation. Also we review here other compensation results produced by spherical and aspherical optics in diode-pumped high power laser oscillators where there is sufficiently increased output power and beam quality (see \cite{3} and references therein).

This work was supported by Sandia National Laboratories through contracts 444259, 618301, 748192, 1012071, and 1012097. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy’s National Nuclear Security Administration under contract DE-AC04-94AL85000.

References:

\begin{itemize}
\end{itemize}