Micro-domain control toward new lasers

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The solid-state lasers and nonlinear optics have contributed to broadening the new horizon in quantum electronics, owing to their high-brightness nature of giant pulses under Q-switching and mode locking[1]. Moreover, their cutting edges are expected from the field of high-energy physics (i.e., laser fusion/laser ignition, laser accelerator, and vacuum decay) to precise measurement, laser-based material processing, and laser ignitions (i.e., engine ignition and fusion ignition). On the other hand, its development has long been a materials-limited. In this talk, we'd like to review the recent progress of **Micro Solid-State Photonics** with regard to high performance microchip lasers based on the micro-domain structure and boundary-controlled materials[2,3]. The past decade has witnessed a veritable revolution in the types and performance levels of solid-state lasers, largely due to development of micro-domain engineered new optical materials, such as the transparent laser ceramics. Especially, the naturally bonded composite Nd:YAG/Cr:YAG ceramics contributes sub-ns giant pulse generation. These progress of YAG ceramics enabled multi-megawatt microchip lasers, sub-PW/sr-cm^2 brightness and sub-ZK brightness temperature. "The world first laser ignited car" has been demonstrated by it[4] (Fig. 1). And furthermore, we'd like to discuss the next generation of high-brightness lasers based on the aligned anisotropic ceramics by RE^{3+}-ion, such as Yb:FAP ceramics. The fabrication of laser-grade anisotropic ceramics by a conventional sintering process is not possible owing to optical scattering at randomly oriented grain boundaries. We have demonstrated the first realization of transparent anisotropic ceramics by using a new crystal orientation process based on large magnetic anisotropy induced by 4*f* electrons (Fig. 2). By slip casting in a 1.4 T magnetic field and subsequent heat treatments, we could successfully fabricate laser-grade calcium fluorapatite ceramics, and its laser oscillation to complete the laser ceramics map as shown in Fig. 3[3,5,6]. These compact lasers can provide the extreme giant-power by using micro solid-state photonics, so to speak "**Giant Micro-photonics**"[1,2].

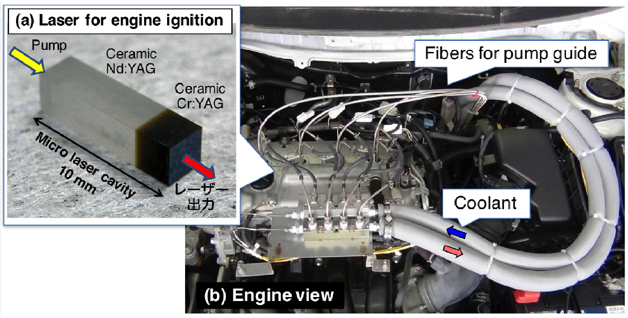

Fig.1. The world first laser ignition engine car by the giant pulse micro laser in Nd:YAG/Cr:YAG transparent laser ceramics.

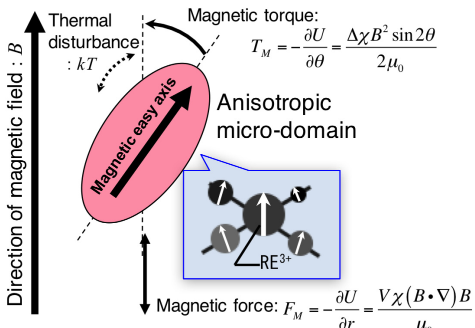

Fig.2. Schematic of the RE-assisted magnetic orientation method for fabrication of RE-doped anisotropic laser ceramics

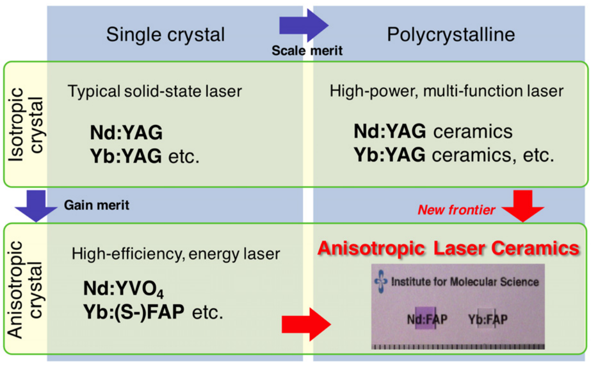

Fig.3. Progress map of solid-state lasers from isotropic single crystals to anisotropic laser ceramics.

Reference

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