Novel Faraday rotators for high-power laser machinery

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The demand for laser machinery and laser markers that are used to cut, join and engrave on various materials including metals, is increasing continuously. These are equipped with a near infrared fiber laser, i.e. a high-output light source consisting of an assembled LDs and an optical fiber amplifiers. These high-power lasers require the use of optical isolators in order to protect the original light sources from back-reflections, which can destabilize the operation of the lasers or even destroy the LDs.

$Tb_3(Sc_{1-x}Lu_x)_2Al_3O_{12}$ (TSLAG) single crystals have been grown and investigated for the first time for magneto-optical isolator applications, especially for high-power laser machinery. $Tb_3Al_5O_{12}$ (TAG) exhibits the best magneto-optical features, however its incongruent melting nature has lead to the industrial use of $Tb_3Ga_5O_{12}$ (TGG). $Tb_3Sc_2Al_3O_{12}$ had been proposed as alternative to TAG, but unfortunately its growth also presents several drawbacks. Present investigation shows that by the isovalent substitution of Sc^{3+} by Lu^{3+} in the octahedral site of the garnet structure, it is possible to improve the growth characteristics while preserving the superior magneto-optical properties. We demonstrate that TSLAG single crystals show a higher visible transparency and a larger Faraday rotation than TGG crystals. TSLAG is therefore very promising material in particular for new magneto-optical isolator applications in the visible-near IR wavelength region. Based on these achievements, Fujikura Ltd. successfully commercialized and marketed TSLAG and a TSLAG-integrated optical isolator in 2013.

CeF_3 and PrF_3 single crystals are also demonstrated as promising Faraday rotator in the UV-visible wavelength region. They possess a high transparency down to the cut-off at about 300 and 220 nm, respectively, as well as an outstanding Verdet constants in the UV wavelength region. The fabrication of CeF_3 optical isolators, operating at 355 and 405 nm, is demonstrated for the first time.

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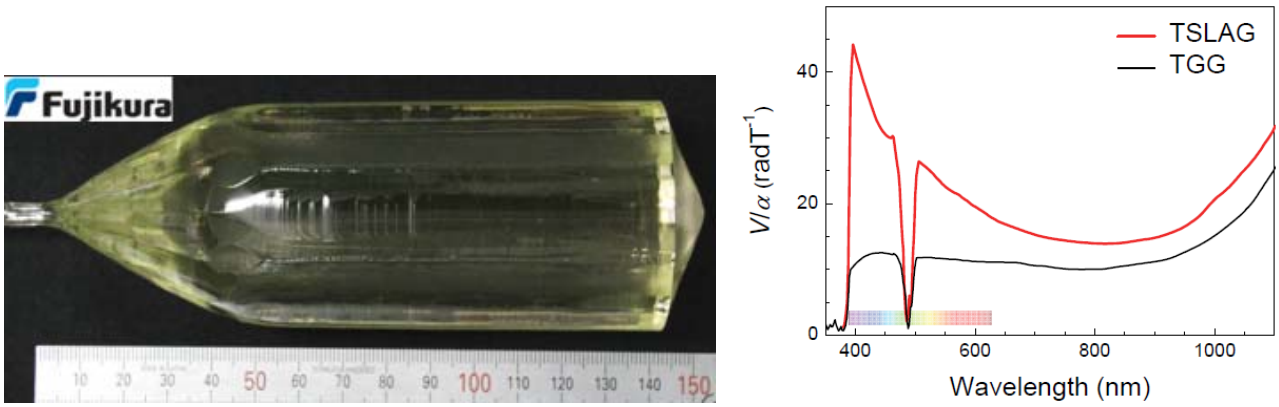

Figure 1: 2 inch TSLAG single crystal (left), and figure of merit comparison between TSLAG and conventional crystal, TGG (right).