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A $(BiY)_3Fe_5O_{12}$ Waveguide with Stripe Magnetic Domain for a Magnetless Optical Isolator

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Optical isolators are indispensable not only in optical fiber communication[1] but also in optical data processing since optical amplifiers and optical functional devices usually have no directionality for signal light. For the application to optical data processing, it is desirable that optical isolators have a size comparable with OEIC's and optical IC's. To construct a optical isolator utilizing a ferri-magnetic garnet as a Faraday rotator, however, a big and heavy magnet is necessary for arranging magnetization in the Faraday rotator parallel to the light axis[2]. In this paper, we demonstrate a Faraday rotator operating without a magnet for a magnetless optical isolator.

To fabricate the Faraday rotator, $(BiY)_3Fe_5O_{12}$ (3 um thick) was first grown on $(\bar{1}10)$ Ca-Mg-Zr-substituted $Gd_3Ga_5O_{12}$ (GGG) substrate by LPE method. The photograph of magnetic domain for $(\bar{1}10)$ $(BiY)_3Fe_5O_{12}$ is shown in Fig.1(a), while that of the conventional magnetic domain for (111) is shown in Fig.1(b). Both were measured by the Bitter method. As shown in the figure, the $(\bar{1}10)$ $(BiY)_3Fe_5O_{12}$ has stripe domain which has a structure of magnetizations as shown in Fig.2. The stripe domain was obtained by using the growth-induced magnetic anisotropy[4]. The growth direction was chosen to be $\langle\bar{1}10\rangle$ to realize the storipe domain[5].

A slab waveguide was made and magneto-optical characteristics were measured using the experimental setup shown in Fig.3. We confirmed a Faraday rotation angle of 150 deg./cm without an external magnetic field under the condition that the lightwave is guided palallel to the stripe domain. The Faraday rotator has an extinction ratio of 13 dB. The photographs of the guided lightwaves are shown in Fig.4; at the extinction angle (a) and at 90 deg. off the extinction angle (b). These results show that a new Faraday rotator operating without a magnet has been obtained.

The new Faraday rotator weights 10^{-3} times lighter and measures 10^{-2} times smaller than the conventional one with a magnet. As a result, an optical isolator having a size comparable with OEIS's and optical IC's can be constructed. Furthermore, this provides the possiblity of hybrid or monolithic integration of optical isolators with them, which will be useful for optical fiber communication and optical data processing.

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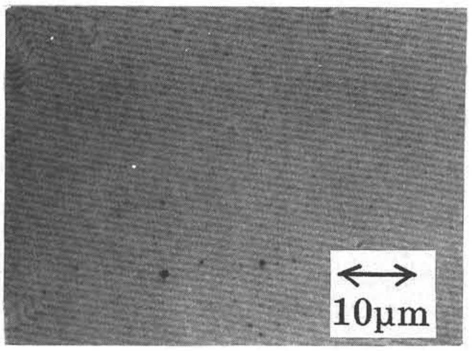


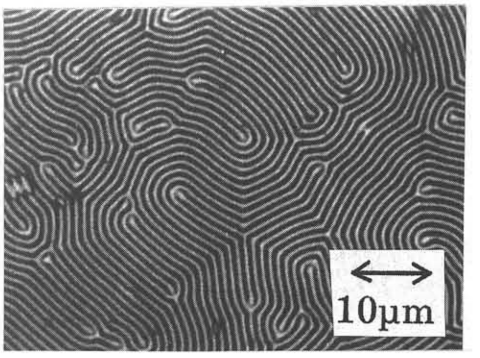
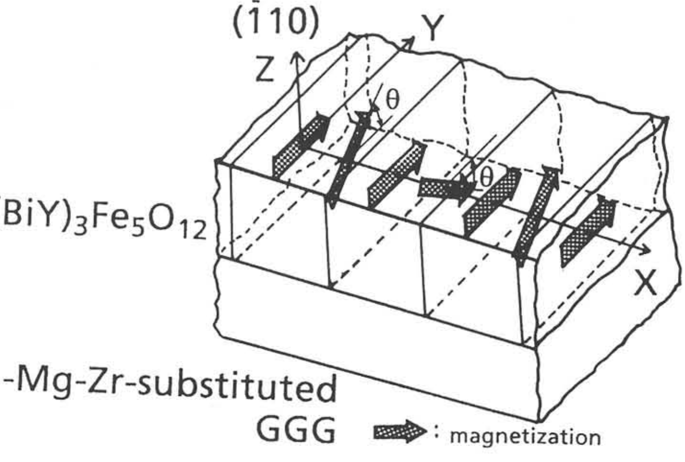


Fig.1 Photomicrographs of magnetic domains measured by Bitter method: (a) a magnetic domain for (110) $(BiY)_3Fe_5O_{12}$ and (b) a conventional magnetic domain for (111).

Fig.2 Schematicdiagramof the magnetization in the stripe domain[3]. The directions of magnetization tilt upward and downward from the direction parallel to the stripe in every other domain.



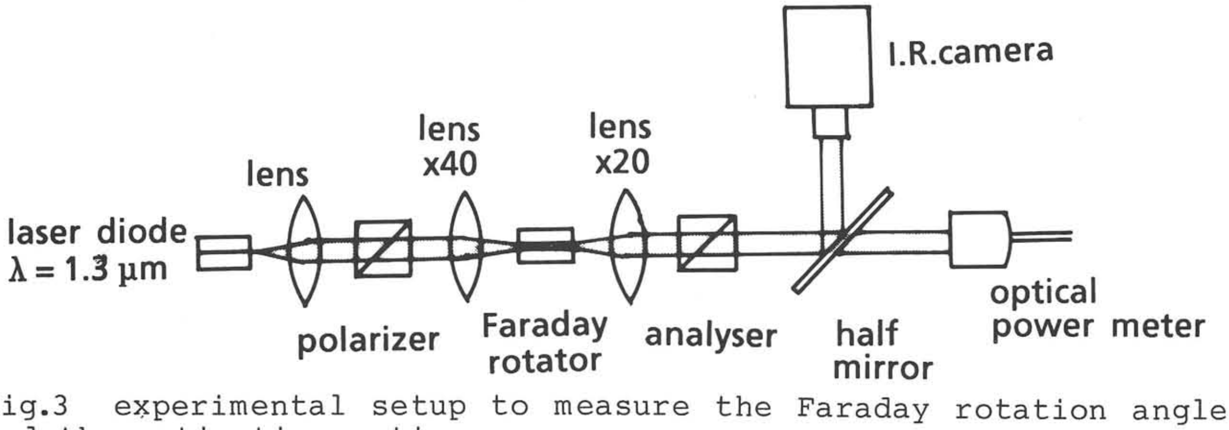
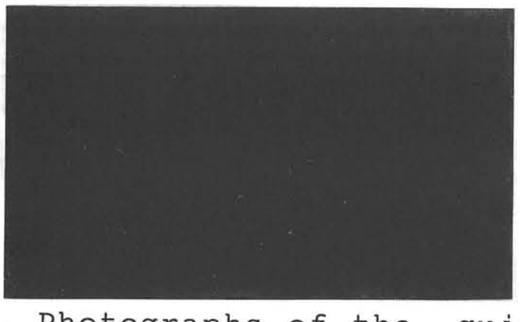


Fig.3 experimental setup to measure the Faraday rotation angle and the extinction ratio.



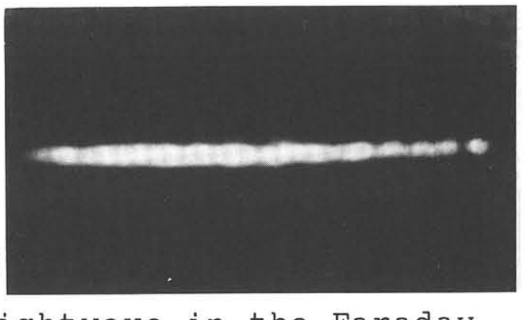


Fig.4 Photographs of the guided lightwave in the Faraday rotator: (a) with the analyzer set at the extinction angle and (b) at the angle of +90 deg.