磁気ナノフォトニクスの開拓に向けた 絶縁体上単結晶磁気光学ガーネット薄膜基板の作製

Fabrication of Monocrystalline Magneto-optical Garnet Thin Film on Insulator Substrates for Exploring Magneto-nanophotonics

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Magneto-optical (MO) materials are essential for inducing nonreciprocal optical phenomena and realizing various optical elements such as Faraday rotators and optical isolators. Monocrystalline yttrium iron garnet (YIG) is one of the most successful materials because of its moderate MO effect with low loss at telecom wavelengths. Nano-structuring such materials will enable further MO devices with extended functionalities, as have been examined in theoretical studies [1,2]. However, experimental progress of this direction is rather limited partly due to the absence of high-quality MO thin-films on suitable handling substrates. Here, we propose and investigate wafer-bonding-based fabrication of MO-material-on-insulator (MOI) substrates as a starting point for exploring MO nanophotonics. In this correspondence, we report the progress of adhesive wafer bonding and grinding of monocrystalline YIG on silicon for thin film formation.

For the formation of the MOI structure, we firstly prepared a Bi-substituted YIG wafer with a thickness of 240 μm and a Si substrate coated with spin-on-glass (Fig. 1(a)). Subsequently, we activated the surfaces by exposure to air plasma created with a power of 200 W (Fig. 1(b)). Right after the activation, we bonded the two substrates by manually applying a pressure of ~ a few MPa (Fig. 1(c)). Currently, we avoid annealing the samples, since it often resulted in delamination probably due to mechanical stress induced by the mismatch in heat expansion of the materials. Then, physical grinding was performed to thin down the bonded YIG substrate (Fig. 1(d)). By changing the particle size in slurry from 9 μm to 100 nm, we controlled the grinding rate as well as roughness of the ground surface. Figure 2 shows a photograph of a ground sample with a YIG thickness of ~ 8 μm. Further thinning to several hundreds of nm and polishing for high surface smoothness will be the next step of development.

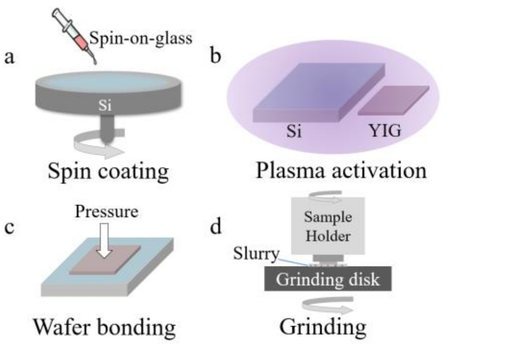

Fig. 1. Fabrication process flow. **a)** Spin coating of spin-on-glass; **b)** Sample surface activation; **c)** Wafer bonding; **d)** Grinding.

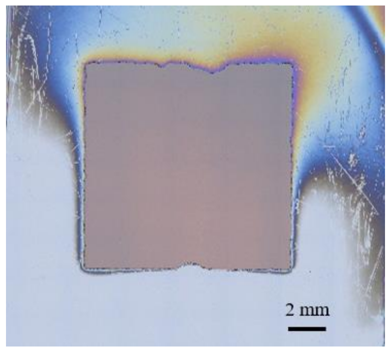

Fig. 2. Optical image of a fabricated MOI substrate.

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