Optical isolator in silicon photonics using sputtered deposited YIG

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I. INTRODUCTION

An optical isolator is a device which is used in optical communication system to suppress backward propagating signal. Commercially available isolator is of bulk type and generally consists of two polarizers with polarization axes offset 45^0 and a Faraday rotation element usually Yttrium Iron Garnet (YIG) or a Ce substituted YIG. The main working principle behind bulk isolator is the Faraday rotation of incident light with the inclusion of external longitudinal magnetic field.

The miniaturization of optical isolator and effort to on-chip fabrication with other opto-electronic components has been done for a no. of years. The strong reason behind choosing the most promising material as YIG or Ce: YIG because of its high Faraday rotation and low optical absorption at infrared range [1-2].

In this paper we are going to present the first time successful deposition report of magnetic material (YIG) on top of silicon platform at IMEC by magnetron sputtering which will be promising technique for integrated optical isolator. Lift-off of garnet and the post annealing of amorphous films were carried out. Some optical and magnetic properties also studied.

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II. EXPERIMENTAL METHODS

We have used some 3.5 mm long straight waveguides with grating couplers meant for transverse magnetic mode (TM). We have used the TM waveguides throughout our experiments because waveguide with magneto-optical material on top of it can isolate only TM mode light [3-4]. We have used 20 waveguides, out of them 10 are board 10 micron wide throughout its length and rest of them are tapered from 10 micron down to 3 micron. We have followed a simple trick to measure the optical losses by comparison method like covering few waveguides by YIG and keeping rest of them as free from YIG so that we can do light transmission measurements through all the waveguides with same optical alignment. Before to deposit YIG on top of the 220 nm thick silicon waveguide we have covered the selected portions of SOI by some positive photoresist to get YIG on that particular portion only. Magnetron sputtering being carried out for 30 minutes with 16 sccm (cubic centimeter per minute at STP) of Ar and 4 sccm of Oxygen keeping the target bias voltage as 200 kW. The length of YIG as deposited on waveguide was 2 mm. These deposited films were then taken for lift off test by using Acetone, IPA and finally by DI water. Finally we used rapid thermal annealing (RTA) at 800^0 C for 2 minutes with Oxygen (200 ppm) environment to make the amorphous film as crystalline one. The XRD analysis clearly shows the difference between annealed and not annealed samples.

III. Results

The XRD scan (θ-2θ scan) was carried out both for annealed and not annealed samples. The spectra in fig.1 clearly depicting the fact that annealing gives the crystalline phase of YIG [5].

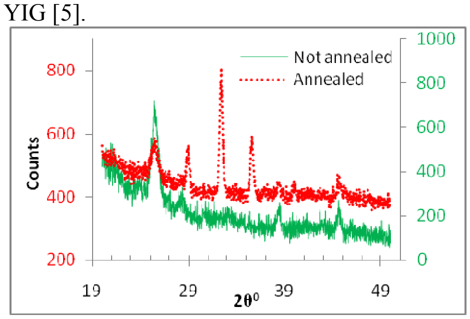

Fig.1. XRD spectra of YIG

Alternating gradient field magnetometer (AGFM) has been used to get an estimation of magnetic properties of both annealed and not annealed YIG samples. Fig.2 shows the hysteresis loops both for annealed and not -annealed YIG.

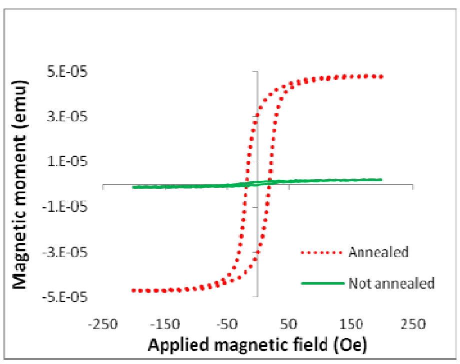

Fig.2.Hysteresis loops of YIG

Optical power transmission measurement has done by using some tunable laser. Polarization of input light is being controlled by Fiber polarization controller to make sure that input was light TM mode. Input and output fiber coupler was single moded.

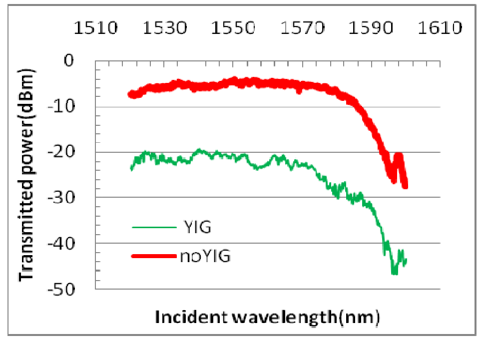

Fig.3. Optical transmission measurement

IV. Conclusion

The annealed YIG on silicon substrate was very rough. The annealed samples not showing any cracks apparently. The Hysteresis loop reveals strong in-plane magnetization for annealed YIG which is strongly desirable for thin film isolator. The optical loss is approximately7.5 dB/mm. The reasons behind high optical loss still to be find out.

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