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All Solid State Spatial Light Modulator by using Magnetic Epitaxial Film

Jaehyuk Park [1&3], H. Takagi[1], Jaehak Park[2], Jaekyeong Cho[3], K. Nishimura[1] and M. Inoue [1&4]

[1]Department of Electrical & Electronic Engineering, Toyohashi University of Technology,
1-1 Hibari-Ga-Oka, Tempaku, Toyohashi 441-8580, Japan
Phone and Fax : +81-532-44-6749, E-mail : park@maglab.eee.tut.ac.jp
[2]Department of Electronic Materials Engineering, Gyeongsang National University,
900 Gazwa, Jinju, Gyeongnam 660-701, Korea
[3]ASTF, [4]JST-CREST

1. Introduction

Spatial light modulators (SLMs) are key components of optical correlator, optical computer and holographic data storage. Various types of reusable modern SLMs with two-dimensional arrays of pixels have been intensively developed over the past three decades. Of these, magnetooptic spatial light modulators (MOSLMs) have the advantages of high switching speed, robustness, nonvolatility, and radioactive resistance. It took the advantage of the nonreciprocity of the Faraday effect, used thinner garnet film, and had a high resolution with narrower pixel gaps. However it still needed the difficult fabrication processes physically isolating the pixels and a rather high drive current to produce a magnetic field high enough to nucleate pixels. For the first time, we report all solid state magneto-optic spatial light modulator without the artificially isolated pixels and external bias coil in this study.

2. Fabrication of novel MOSLM

The novel MOSLM is fabricated by the combinatory use of the effect reduced the magnetization of pixel areas at LPE garnet film by local annealing and the effect of metallization stress on magnetic domain walls. The novel MOSLM can provide the improved resolution, the simple fabrication process and very low driving current. It is also possible to make the application to the microdisplay like FLC-SLM and DMD. The substrate was fabricated by slicing a Chocralski grown single crystal gadolinium gallium garnet boule with Ca, Ma and Zr substitution to expand lattice. Bi-substituted iron garnet film of $(BiGdY)_3$ $(FeGa)_5$ O_{12} was epitaxially grown on the substrate. The thickness of the film was about 4 μm. Figure 1 shows the magnetic hysteresis loops of the epitaxial film. The novel MOSLM had the layer structure of substrate (SGGG) / magnetic garnet $(BiGdY)_3$ $(FeGa)_5$ O_{12}, (4 μm) / patterned Si (200 nm, pixel) / SiO_2 (200 nm) / Al (400 nm, X conductor) / SiO_2 (400nm) / Al (400 nm, Y conductor) as shown Fig.2. An silicon layer 0.4 μm thick as the areas of pixels is ion beam sputter deposited on patterned image reverse photoresist and lift off process is done. The epitaxial film having the patterned silicon (size:15*15 μm and pixel gap: 2 μm) was annealed using IR for 10 min at 900'C. During the annealing process, the silicon in the layer reduces oxygen from the surface of the LPE garnet film. The oxygen vacancies cause Fe^{2+} ions to be produced in the epitaxial layer. The presence of these oxygen vacancies or the Fe^{2+} ions causes local distortions to be produced in the lattice which reduces the relaxation time for transfers of gallium ions between octahedral and tetrahedral sites. A redistribution of the gallium ions occurs in the annealing step at much lower temperatures or shorter times, or both, than without the silicon layer on the layer. The pixels then have a low anisotropy. The pixels may have two times smaller magnetization $4\pi M_s$ than the areas outside of the pixels. This in turn causes the epitaxial layer at the positions of the pixels to have properties which provides for an easier switching of magnetization of the layer at the pixels than the areas between the pixels. The edge of the patterned silicon generates the stress field in epitaxial garnet layer. By such stress field, the domain wall energy under the patterned silicon is substantially perturbed in the immediate vicinity of edge. This gives rise to either an attractive or repulsive interaction, depending on the signs of the stress and of the magnetostriction coefficients. As the domain wall energy is substantially perturbed in the immediate vicinity of edge by such stress field, it is effective for clearly separating the pixels. Figure 3and 4 show the micrograph of the magnetized pixels separated by these two effects and the fabricated MOSLM, respectively. Figure 4 shows the switching properties of the MOSLM by carrying the currents of 10mA for X conductor and 20mA for Y conductor, respectively.

3. Conclusions

All solid state magneto-optic spatial light modulator without the artificially isolated pixels and external bias coil is fabricated. The novel MOSLM can provide the improved resolution, the simple fabrication process and very low driving current. It is also possible to make the application to the microdisplay like FLC-SLM and DMD.

References

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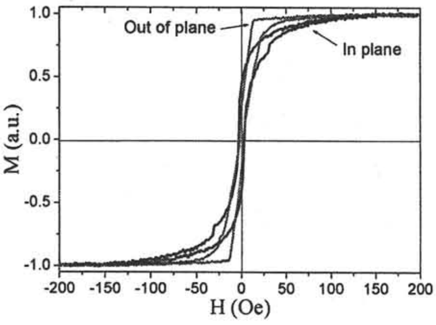

Fig. 1. Magnetic hysterisis loops of the epitaxial film

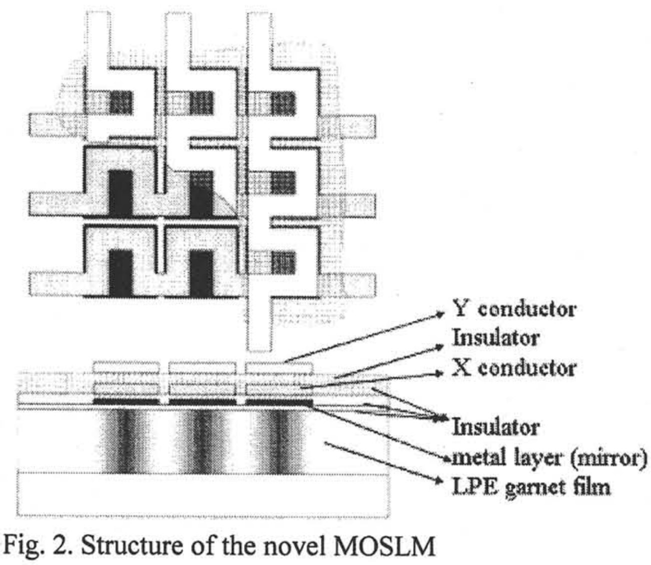

Fig. 2. Structure of the novel MOSLM

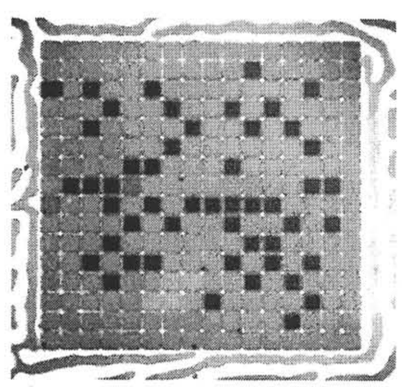

Fig.3. the micrograph of the magnetized pixels at the novel MOSLM

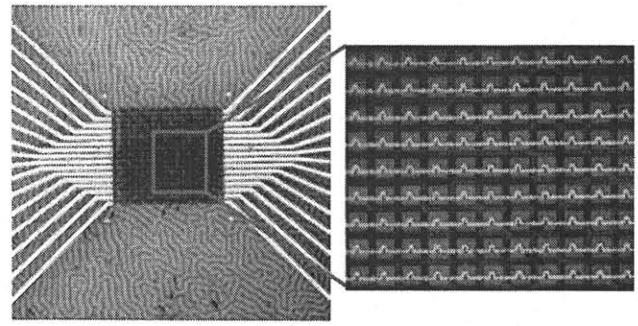

Fig. 4. The optical micrograph of X conductor at the fabricated MOSLM.

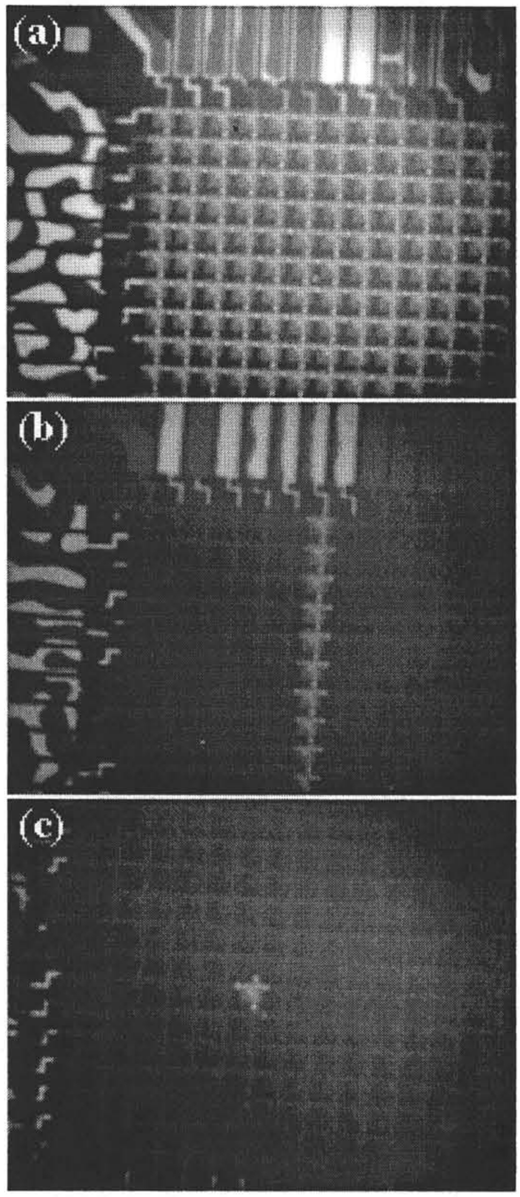

Fig. 5. Switching properties of the MOSLM by carrying the currents of 10 mA for X conductor and 20 mA for Y conductor, respectively : (a) total pixels; (b) a row of pixels, and (c) single pixel.