パルスレーザー堆積法による相分離型 $CoMnGaO_4$ 薄膜の作製

Fabrication of $CoMnGaO_4$ thin films with phase separated-structure

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Nanostructured thin film material is applied in different areas to improve its performance. However, the traditional method to make nanostructure in oxide thin film is complicated, expensive and need lots of processes to deal with it. To overcome these disadvantages, the self-organization and phase separation in oxide thin film may be useful. Some groups reported a crystal phase separation phenomenon in bulk and thin film manganite with a nano-checkerboard structure[1,2]. This might be a candidate way to realize nanostructure in other kinds of film.

Recently, we reported some results about the fabrication of p-type CoGa2O4(CGO) thin film and its photoelectrochemical properties [3]. CGO thin film shows a p-type behavior and a photovoltaic phenomenon also is observed. As the doping ration of Mn3+ ion gets higher, the electrical properties of CGO thin film changed gradually and finally become an n-type semiconductor when the content becomes CoMn2O4(CMO). These two different semiconductors' behavior gives a possible way to realize bulk heterojunction in thin film utilize the phase separation method mentioned before.

In this study, we focused on spinel-type $CoMnGaO_4$(CMGO). The CMGO thin films were fabricated using a pulsed laser deposition (PLD) and the dependence of substrates and annealing conditions on their crystalline structure were investigated. The substrate temperature and oxygen pressure during the film deposition were maintained at 700℃ and 0.1Pa, respectively. Single crystalline plates of STO:Nb (100) and $MgAl_2O_4$ (100) were employed as substrates for film growth. Annealing time was 150 hours and temperature was 375℃. Fig.1 shows the XRD patterns of CMGO films before and after annealing.

The CMGO films show a distinct split of XRD peak after annealing and the split two peaks are assigned to the (400) reflection peaks of $CoMn_2O_4$ and $CoGa_2O_4$, respectively. The films formed on MAO substrates showed similar peak splitting. The possible reason for this splitting is the activation of the Jahn-Teller effect of Mn^{3+} and then the JT Mn^{3+} cluster together make two different crystal phases.

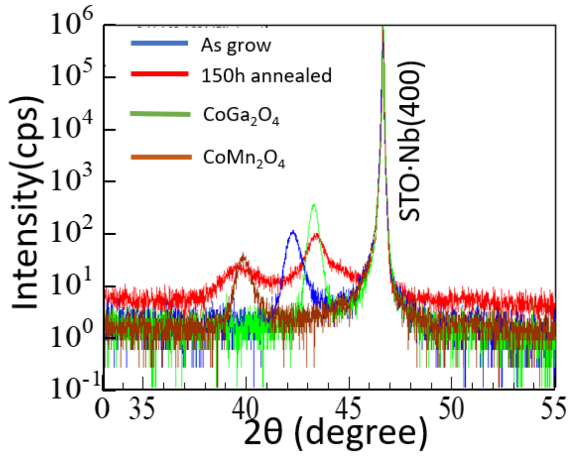

Fig.1 XRD pattern of CMGO film on STO substrate around the peak of spinel (400) reflection.

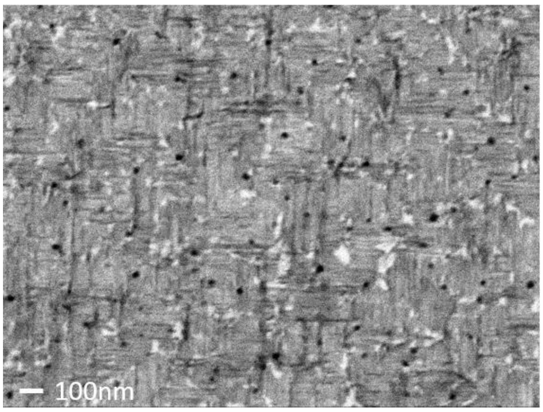

Fig.2 SEM image of CMGO film on STO substrate.

Figure 2 shows the SEM image of CMGO thin film on STO:Nb substrate. Checkerboard-like patterns were observed and we found that their directions are parallel to [010] and [001] directions. The dependence of nanostructures on the physical properties of CMGO films will be discussed.

Reference:

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