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Enhancement of Au induced lateral crystallization in electron irradiated amorphous Ge on SiO_2

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Abstract

We have investigated the electron irradiation effect of Au induced lateral crystallization for amorphous Ge on SiO_2. The lateral growth velocity can be successfully enhanced by high energy (2MeV) electron irradiation. We have speculated that the growth enhancement is due to the introduction of the defects into amorphous Ge able to diffuse easily of Au atoms.

1. Introduction

Metal induced crystallization (MIC) methods [1-3] have been widely investigated for the fabrication of high performance thin film transistors and solar cells. However, long annealing time for MIC is necessary due to the slow growth velocity at low temperature (~ 400 ^{o}C). To solve this problem, growth velocity of MIC should be enhanced. In line with this, we have examined the initial amorphicity modulation in amorphous Ge (a-Ge) by electron irradiation in order to enhance the Au induced lateral crystallization of a-Ge on SiO_2/Si substrate.

2. Experiments and Results

The experimental procedure is schematically shown in Fig. 1. A-Ge films (100 nm thick) were deposited on SiO_2/Si substrate by using sputtering system at room temperature. These samples were irradiated with or without electron beam (acceleration energy: 0.5 ~ 2.0 MeV, fluence: ~ 5×10^{17} e/cm^2) at room temperature using the electron accelerator at Takasaki Japan Atomic Energy Agency (JAEA). Consequently, Au films (200 nm thick) were deposited on a-Ge films. The Au films were patterned into circular shape using a metal mask during the evaporation. Finally, these samples were annealed at 400 ^{o}C in N_2 ambient. They were evaluated by Nomarski optical microscopy and electron spin resonance (ESR) spectroscopy.

Nomarski micrographs of the samples without and with various electron irradiation conditions after annealing at 400 ^{o}C for 60 min are shown in Fig. 2. In all samples, the lateral growth region was observed at around Au pattern. Particularly, the lateral growth region of 2.0 MeV electron irradiated sample is larger than that of other samples. To detail investigation for the influence of electron irradiation, the lateral growth length was estimated by Nomarski micrographs. Figure 3 show annealing time dependence of lateral growth length for samples without and with various energy electron irradiations. In the case of sample with 2.0 MeV electron irradiation, the lateral growth length was significantly expanded compared to the sample without electron irradiation.

In order to evaluate the influence of acceleration energy, the lateral growth velocity of the samples with electron irradiation were normalized at the velocity without electron irradiation. Thus, the normalized growth velocity is larger than 1.0, which shows that the lateral growth is enhanced by electron irradiation. Figure 4 shows electron fluence dependence of normalized lateral growth velocity for the samples with various energy electron irradiations. In the case of samples with low energy electron irradiation (~ 1.0 MeV), the normalized velocity was found to be nearly 1.0, which means electron irradiation was not effective. On the other hand, the normalized velocity with high energy electron irradiation (2.0 MeV) was found to be nearly 1.7. Therefore, the lateral growth velocity was enhanced by high energy electron irradiation.

The total number of defects into a-Ge evaluated by ESR measurements is shown in Fig. 5. In the case of sample with high energy electron irradiation (2.0 MeV), many defects were introduced into a-Ge thin films. It is known that Au atom diffusion is mediated by Ge defects via [4]. Consequently, the Au atom diffusion mediated by Ge defects was enhanced, due to high energy electron irradiation. These results suggest that Au induced lateral crystallization of a-Ge on SiO_2 was remarkably enhanced by high energy electron irradiation able to diffuse easily of Au atoms.

3. Conclusion

We have examined the initial amorphicity modulation in a-Ge by electron irradiation for Au induced lateral crystallization. As a result, the Au induced lateral crystallization was remarkably enhanced by high energy electron irradiation. This enhancement is attributed to the easiness of Au atoms diffusion into a-Ge. This technique is very useful to realize high performance thin film transistors and solar cells.

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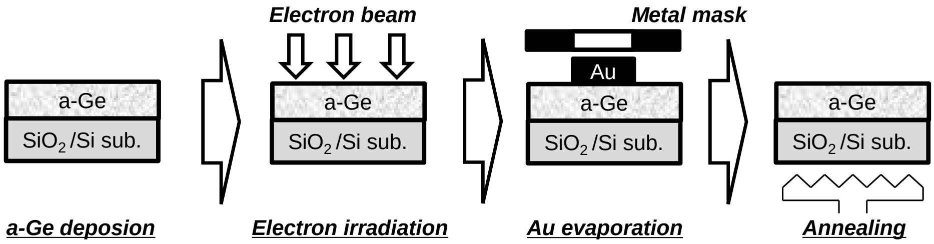

Fig. 1 Experimental procedure.

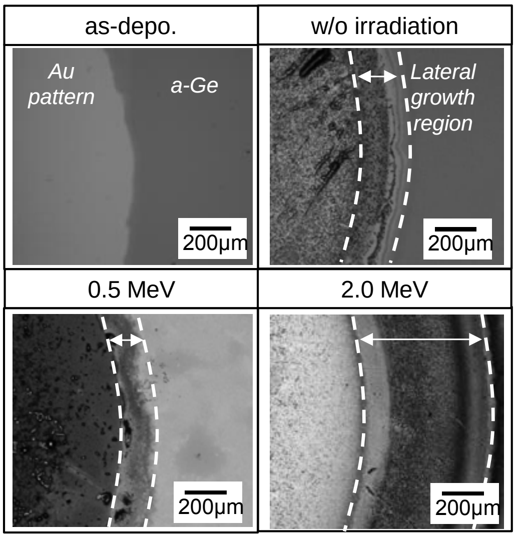

Fig. 2 Nomarski micrographs of the samples with and without various electron irradiation conditions after annealing at 400 °C for 60 min (Electron fluence : 1×10^{17} e/cm^2).

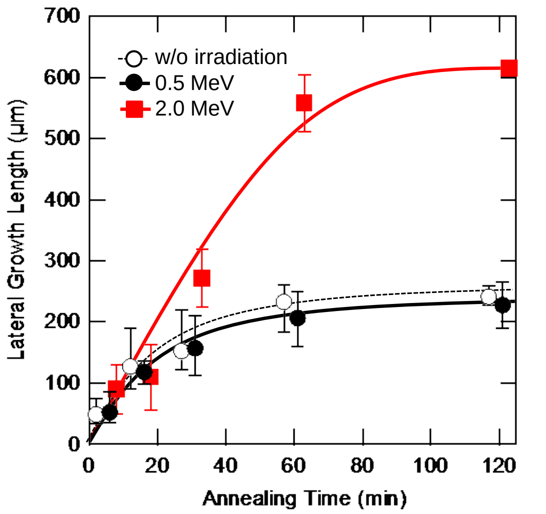

Fig. 3 Annealing time dependence of the lateral growth length of the samples with and without various energy electron irradiations (Electron fluence : 1×10^{17} e/cm^2).

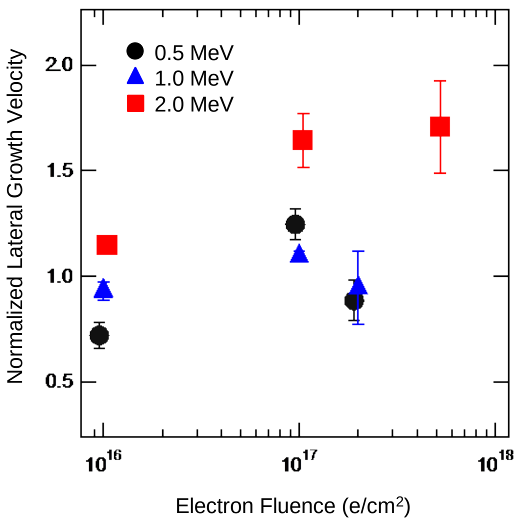

Fig. 4 Electron fluence dependence of normalized lateral growth velocity for the samples with various energy electron irradiations.

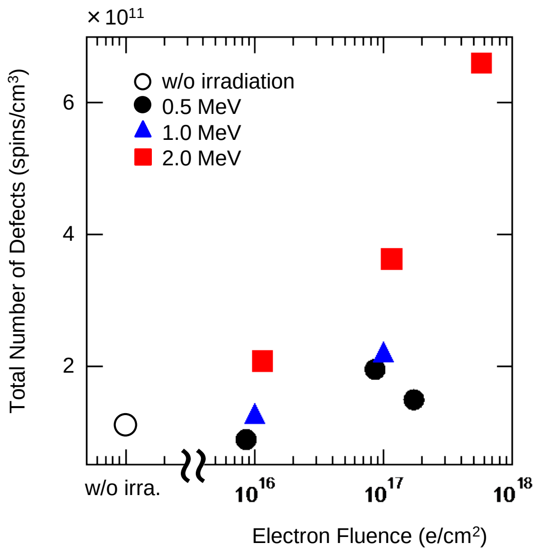

Fig. 5 Electron fluence dependence of total number of defects for the samples with and without various energy electron irradiations.