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Fabrication of crystalline Ge films using RF sputtering and metal catalyst
RFスパッタリングと触媒金属を用いたGe結晶薄膜の作製

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We report rapid formation of crystalline Ge thin film between Au catalyst film and quartz glass substrate using a radio frequency (RF) magnetron sputtering method. The formation speed is much faster than that of metal-induced crystallization. The deposition rate of crystalline Ge film between Au film and glass substrate is proportional to the deposition rate of Ge on Au film. We achieved the maximum formation rate of crystalline Ge thin film under Au film is 6 nm/min.

1. Introduction

Ge is promising material for various functional devices such as high speed transistors and high efficiency solar cells, because Ge has higher carrier mobility and narrower band gap than Si. For solar cell materials, Ge has an inherent advantage over Si since Ge is known to exhibit much larger absorption coefficient of infrared light than Si, and high power conversion efficiency is expected for such high solar light absorption [1]. To realize high efficiency solar cells using Ge, fabrication of high quality Ge thin films is important. Metal-induced crystallization (MIC), utilizing catalytic metals for lowering the crystallization temperature of semiconductor such as Ge and Si, can be employed to form high quality and highly aligned crystalline Ge films between metal films and substrate at a relatively low annealing temperature [2-6]. However, the process needs quite a long annealing time above 10 hours. In this study, we report rapid fabrication of crystalline Ge films between Au films and quartz glass substrate using magnetron sputtering method to reduce the conduct time.

2. Experimental

First, Au films were deposited on quartz glass as catalyst by sputtering method. The sputtering of Au was carried out at a power of 1.5 kVA and a working pressure of 2.0 Pa. The thickness of Au film was 30 nm.

Then, Ge films were deposited using 13.56 MHz RF magnetron sputtering reactor. Figure 1 shows a schematic of experimental reactor for Ge film fabrication. Ar gas was supplied at 80 sccm and the pressure was 0.005 Torr. The applied RF power was 50 W. The quartz glass was located at 50 mm from the cathode and the temperature was 180 ^{o}C. The sputtering target was a poly-crystal Ge disk (1 inch) with a purity of 99.99 %.

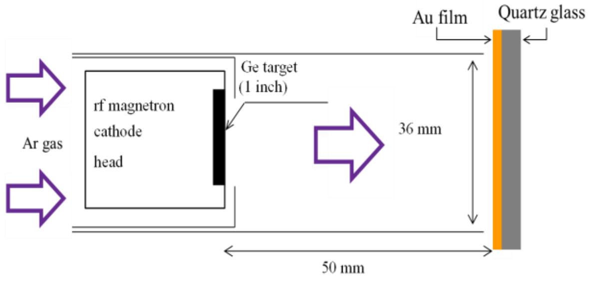

Fig.1. Experimental apparatus of RF magnetron sputtering.

3. Results and discussion

We have measured depth profile of compositions of films by auger electron spectroscopy (AES). Figures 2 (a) and (b) show images of quartz glass surface deposited Au film before and after depositing Ge films, respectively. The red closed circles in Fig. 2 (b) show measured positions by AES.

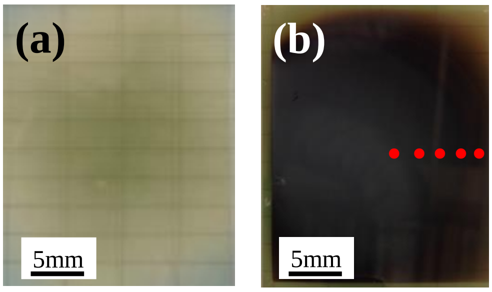

Fig. 2. Images of substrate surface before and deposition of Ge film.

Figure 3 shows a typical depth profile of Ge, Si and Au concentrations. Ge concentration shows a strong intensity from surface to 235 nm in thickness. Au concentration increases from 235 nm and show high intensity between 235 and 280 nm. Then, Ge concentration shows a strong intensity again. This indicates that we succeed in fabrication of Ge film between Au film and quartz glass substrate.

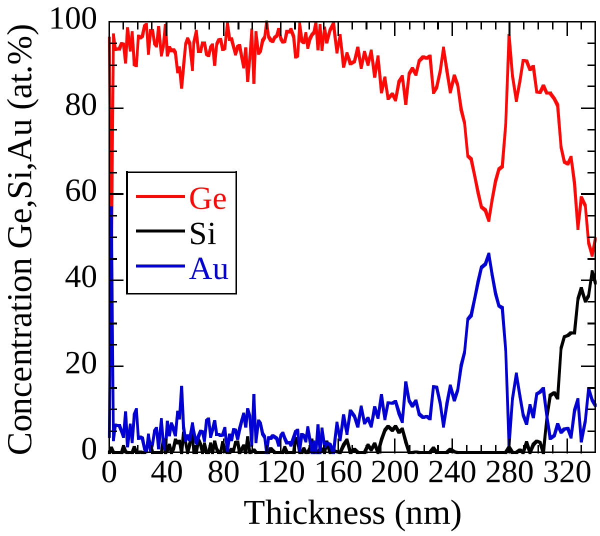

Fig. 3. Typical depth profile of Ge, Si and Au concentrations. 0 nm corresponds to surface.

Figure 4 shows Ge film thickness above and below Au films and their ratio, as a function of deposition rate or flux of Ge atoms. With increasing the deposition rate from 2.62 to 29.4 nm/min and flux of Ge from 1.94 to 21.7 $nm^{-2}s^{-1}$, the thickness of Ge film fabricated between Au film and quartz glass tend to increases from 4.2 to 60.3 nm. The ratio of Ge below Au to above Au is around 20 % irrespective of Ge flux.

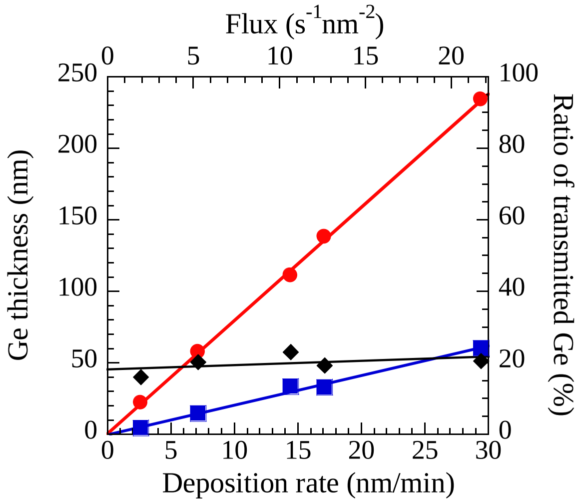

Fig. 4. Ge film thickness above and below Au films and their ratio, as a function of deposition rate or flux of Ge atoms.

4. Conclusions

We succeed in fabrication of crystalline Ge film between Au film and quartz glass with a short period and low temperature compared with MIC method. The ratio of Ge below Au to above Au is around 20 % irrespective of Ge flux.

Acknowledgments

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