PREPARATION OF Si AND Ge THIN FILM BY INDUCTIVELY COUPLED PLASMA ASSISTED REACTIVE SPUTTERING

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\textbf{Introduction} The purpose of this research is to prepare a hydrogenated silicon (Si: H) and a germanium (Ge: H) thin films applicable to solar cells. In this experiment, inductively coupled plasma (ICP) to promote the decomposition of hydrogen is introduced by an antenna coil near the substrate for more efficient reactive sputtering. We examined the effect of the ICP on the film characteristics.

\textbf{Experiment} Fig. 1 shows a schematic diagram of the RF magnetron sputtering apparatus. The distance between targets and a substrate is 18 cm, and the ICP antenna coil is placed at 4 cm from the substrate. SUS 304 is used for the antenna coil, and it is constructed with two windings and a diameter of 6 cm which is slightly larger than a substrate size. The ICP was generated by applying RF power (13.56 MHz) to the antenna coil through a matching box. Ar and H\textsubscript{2} were used as sputtering gases, and Si and Ge were used as targets. The RF power applied to the two target was 200 W and the substrate temperature was 200 °C. In the case of Si: H, a H\textsubscript{2}/(Ar+H\textsubscript{2}) ratio was 40 \%, and a gas pressure was kept at 1 Pa. In the case of Ge: H, a H\textsubscript{2}/(Ar+H\textsubscript{2}) ratio was 70 \%, and a gas pressure was kept at 2 Pa.

\textbf{Results and Discussion} Fig. 2 shows the film deposition rates for Si: H and Ge: H films while changing the ICP RF power from 0 W to 200 W. In both cases, the deposition rates increased with the rise of the ICP RF power. A number of argon ions is probably increased by to the high density plasma of ICP, so the sputtering effect is enhanced. Fig. 3 shows the absorption coefficients of Ge: H thin films with several ICP RF powers as a function of photon energy ICP RF power. The optical absorption coefficients around 0.6 eV decreases as the ICP power increases. It seems that the hydrogen decomposition enhanced by ICP could reduce dangling bonds in the films became of the hydrogen termination by included hydrogen atoms.

\begin{figure}[h]
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\includegraphics[width=0.8\textwidth]{figure1.png}
\caption{Schematic diagram of ICP assisted sputtering apparatus}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{figure2.png}
\caption{Deposition rates of Si: H and Ge: H thin films as functions of ICP RF power.}
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\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{figure3.png}
\caption{Absorption coefficients of Ge: H thin films deposited with several ICP RF powers as functions of photon energy.}
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