Rare earth - doped silicon nitride layers for solar cell applications

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Recent studies of a new class of rare earth- doped silicon nitride based phosphors shows the tuning of the emission wavelength by changing the concentration of a specific rare-earth element \cite{1}. The research was reported for crystalline matrices; therefore, parallel studies on amorphous host silicon nitride layers are considered to be a challenge.

The application of thin silicon nitride layers deposited at high deposition rate as bulk passivating and antireflection coating on crystalline silicon solar cells has already been proven successful in increasing the efficiency of the solar cells \cite{2}. A very recent approach to further increase the efficiency is based on the light conversion mechanism, in which the photons are shifted to a wavelength range where the solar cell has a better or higher response.

The incorporation of a rare-earth material in a silicon nitride crystalline matrix causes the shift of the emission towards the red part of the spectrum, as reported in the literature \cite{1}. The photoluminescence measurements (PL) show that the emission wavelength shifts towards the red part of the spectrum with the dopant concentration.

In this contribution the properties of europium- and samarium- doped amorphous silicon nitride layers are investigated. The silicon nitride doped layers are deposited using a PECVD-sputtering approach in which the layers are deposited in an (remote) expanding thermal plasma from Ar/SiH\textsubscript{4}/NH\textsubscript{3} mixtures, while the rare earth element is sputtered from a target in the proximity of the substrate holder. In order to obtain information about thickness, refractive index, and the composition of the films, Spectroscopic Ellipsometry (SE) and Rutherford Back Scattering (RBS) measurements have been performed, respectively. The photoluminescence properties (PL) have been investigated using a spectrometer equipped with a Xe flash lamp. A preliminary result confirming the incorporation of Sm in the amorphous silicon nitride matrix is depicted in figure 1.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{PL spectra of Sm doped silicon nitride layers using an excitation wavelength of 485 nm}
\end{figure}

Three peaks have been identified to the Sm\textsuperscript{3+} ions and have been assigned to the following electronic transitions: \textsuperscript{4}I\textsubscript{9/2}→\textsuperscript{6}H\textsubscript{7/2} (at \textasciitilde 517 nm), \textsuperscript{4}F\textsubscript{7/2}→\textsuperscript{6}H\textsubscript{5/2} (at \textasciitilde 528 nm), and \textsuperscript{4}I\textsubscript{9/2}→\textsuperscript{6}H\textsubscript{9/2} (at \textasciitilde 540 nm). The amorphous nature of the present silicon nitride matrix could have an influence on the peaks broadening. Complementary to these measurements, the RBS analysis show the presence of Sm in the layers. Therefore, in order to fully understand these results, other measurements and investigations need to be performed.

\cite{1} Y. Q. Li et al., J. Alloys. and Comp. 417, 273 – 279.
\cite{2} J. Hong et al., J. Vac. Sci. Technol. B. 21 (5).