Low-temperature p-type epitaxial silicon growth characterized by in-situ spectroscopic ellipsometry.

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A promising way to reduce the cost of p-n junction formation in crystalline Si solar cell is to use low-temperature growth of doped epitaxial silicon layers. [1] In this work, we have used in-situ spectroscopic ellipsometry to study the process of highly doped epitaxial silicon layer growth. The film was deposited by plasma-enhanced chemical vapor deposition (PECVD) on a crystalline silicon substrate at a substrate temperature of 200 °C. [2] In the deposition process, SiF_4 was used as a precursor, B_2H_6 as doping gas, and a hydrogen/argon mixture as carrier gas. A spectroscopic ellipsometer Woollam M200DI with spectral range from 190 nm to 1700 nm was used for in-situ spectroscopic measurements (see Fig. 1a). Since the temperature during process is 200 °C, the optical functions of silicon differ from these typically used at room temperature (RT) and have to be also modified. The parameters of the silicon model were fitted from in-situ ellipsometric data together with the thickness of the epitaxial layer (see Fig. 1b). As a result, we were able to determine the dynamics of the epitaxial layer growth, namely the initial layer formation time and the epitaxial growth rate. This study opens up new perspectives for understanding and monitoring of the epitaxial silicon deposition processes as the parametric model fitting can be applied directly during the growth at different temperatures.

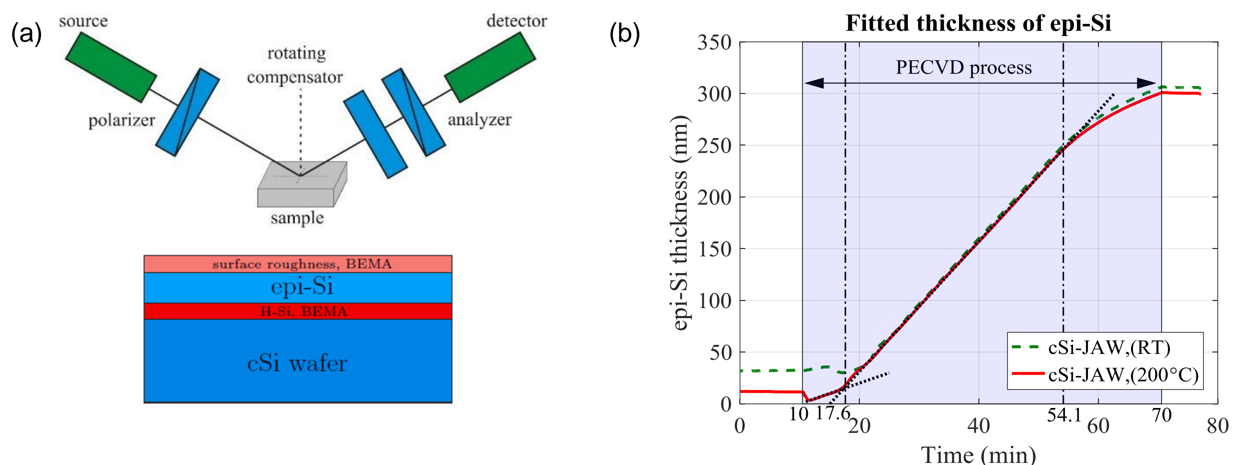

Figure 1. (a) Schematics of the spectroscopic ellipsometer configuration (top subfigure) and multilayered model used for in-situ data fitting (bottom subfigure). (b) Evolution of the epitaxial Si thickness obtained using c-Si optical function at RT and 200 °C. Vertical dash-dot lines mark start of the plasma process (time of 10 min), and end of the plasma process (time of 54.1 min).

[1] M. Moreno, G. Patriarche, and P. Roca i Cabarrocas, “Fine-tuning of the interface in high-quality epitaxial silicon films deposited by plasma enhanced chemical vapor deposition at 200 ˚C,” J. Mater. Res. 28, 1626–1632 (2013).

[2] R. Léal, F. Haddad, G. Poulain, J.-L. Maurice, and P. Roca i Cabarrocas, “High quality boron-doped epitaxial layers grown at 200 ◦C from $SiF_4/H_2/Ar$ gas mixtures for emitter formation in crystalline silicon solar cells,” AIP Adv. 7, 025006 (2017).