Influence of bipolar substrate bias on the layer growth and the composition of the deposited layer

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1. Introduction

For the development of isolating and diffusion barrier layers for thin film solar cells, investigations of the layer growth and its molecular structure are carried out [1]. The SiO_x-layers are deposited in a HMDSO:O_2 microwave plasma, which is generated by the Duo-Plasmaline, a linear expanded plasma source.

The substrate is unpolished steel with a rough surface. Emphasizes is given to the growing layer at position of indentations, where pin holes can develop. To prevent these pin holes, substrate bias is applied which influences the ion flux to the substrate surface.

Variations in the layer composition caused by the applied bias are analyzed with in-situ FTIR spectroscopy, which is installed at the coating chamber. The molecular structure gives information about material properties like adhesion, flexibility and diffusion behaviour.

2. Investigations of the layer growth

By applying a negative bias voltage to the substrate holder, the ions, which are the layer-forming particles, are accelerated perpendicular to the substrate surface, so that they can reach the indentations. Additionally, a positive pulse is needed to neutralize the remaining positive charge on the substrate surface. To obtain the best efficiency of the deposition, the bias voltage is an asymmetric rectangular pulse.

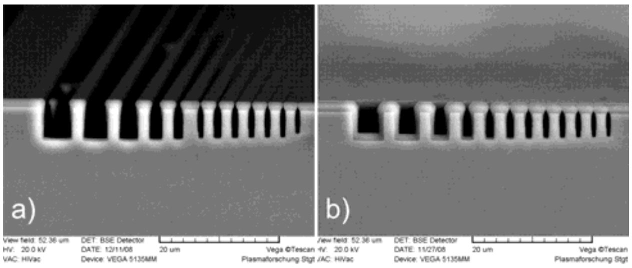

Fig.1 Breaking edge of a coated Si-wafer with a well-defined surface structure: a) without and b) with substrate bias.

To study the layer growth at positions of indentations on the substrate surface, Si-wafers with a well-defined surface structure in the µm-range are used as substrates. Their breaking edge is analyzed in the scanning electron microscope, so that the shape of the coating in the trenches can be directly observed. The coatings produced at different bias voltages and plasma parameters are compared. In Fig. 1, a wafer coated without substrate bias, a) is compared with a biased one, b).

The intention is to fill up the indentations with the deposited layer, so that in the coating no pin holes can be developed.

3. FTIR spectroscopy

The molecular structure of the coatings is directly detected with in-situ FTIR spectroscopy, so that conclusions can be drawn concerning the coating properties as a function of the bias parameters. In Fig. 2, the spectra of the unbiased and the biased coating are compared. They are similar except for an additional peak at $\nu = 956\ cm^{-1}$ due to Si-O vibrations. This indicates that the composition of the coating is modified by biasing the substrate.

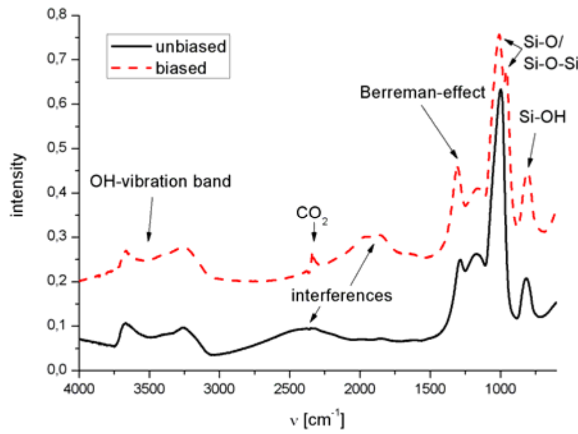

Fig.2 FTIR spectrum of a biased coating in contrast to an unbiased one.

This work is partly funded by the BMBF under the contract number FKZ 03SF0321C.

References

[1] E. Häberle, J. Kopecki, A. Schulz, M. Walker, U. Stroth, Deposition of barrier layers for thin film solar cells sustained by bipolar substrate biasing, submitted to Plasma Processes and Polymers