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Collisional-radiative model of argon plasma for industrial PECVD tool for solar cells production

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Surface wave-sustained plasma discharge is produced by microwave sources around a quartz tube in a low-pressure reactor. This plasma is extensively used in industry for thin layer deposition by plasma-enhanced chemical vapor deposition (PECVD). Optical emission spectroscopy (OES) is an established characterization technique to determine plasma parameters such as electron temperature and density. The advantage of OES is being a fast, easy-to-set-up and non-intrusive technique, ideal for industrial tools if the right models are applied to interpret the emission spectra.
In our study, a collisional-radiative model (CRM) was developed for low-pressure, low-temperature argon plasma to calculate the electron density and the electron temperature in an industrial PECVD tool for solar cell production. The model describes the kinetics of 15 argon excites states (1s and 2p). The plasma parameters were solved for different pressures as well as at different positions from the quartz tube in order to study the plasma homogeneity. To ensure a high sensitivity for the electron density and temperature, a careful attention was taken while choosing the OES lines used for fitting the model to the experimental data. Electron temperature and density are in the range of what is reported in literature for these types of plasmas. Results from CRM are compared to a rather simple corona model, the latter known to be valid for low-pressure plasmas. Radiation trapping was found to play a very important role for excited states population in CRM and for line intensities emitted in OES. Kinetic processes of 1s and 2p levels have been investigated in order to evaluate the importance of every considered reaction in our model.
As a next step, argon was used as a trace gas for the characterization of a real process of silicon nitride SiN_x deposition (using a mixture of silane SiH_4 and ammonia NH_3) for the passivation and anti-reflective coating of crystalline silicon solar cells. The effect of the depositing gases quenching on the argon excited states has been carefully investigated.

Keywords
PECVD
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OES
CRM