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TiN layers as a back contact for chalcopyrite thin film solar cells

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Cu(In,Ga)S(e)$_2$ chalcopyrites are promising absorber materials for thin film solar cells due to its favourable opto-electronic properties. For the selenide Cu(In,Ga)Se$_2$ solar cells efficiencies of more than 20 % were reported recently. In order to reduce the production costs, every layer has to be optimized with respect to material consumption, deposition rate etc. While the expensive indium in the absorber layer can be replaced by tin and zinc, only few attempts have been reported on the replacement of the usual molybdenum back contact by other materials.
In this work, we investigate the substitution of the molybdenum back contact by titanium nitride (TiN), a well known material in other thin film areas, like hard or decorative coatings, diffusion barriers or chemically resistive layers. The chemical inertness, together with the high melting point, the low electrical resistivity (ρ_{bulk}=5×10^{-4} Ωcm), the good adhesion at the interface and low cost of the material make TiN a potential candidate for back contacts for thin film solar cells. Additionally, TiN can be used as a diffusion barrier for sodium from the float glass substrate, which is important for the optimization of the chalcopyrite absorbers.
In this paper, we will present the results on the d.c. reactive magnetron sputtering deposition of TiN$_x$ thin layers on float glass substrates at deposition temperatures below 100 °C and for total sputtering pressures between 0.3 and 2 Pa. The electronic and structural properties of the thin TiN layers were investigated with special emphasis on the intrinsic stress, which has to be minimized. The sputtering pressure in our chamber was optimized with respect to a good film adherence, low intrinsic film stress and a sufficiently low resistivity of up to now 1.1×10^{-4} Ωcm. For the optimal process, the sputtering pressure of 0.5 Pa and Ar/N2 gas flow ration of 3.3 result the discharge voltage of 347 V for 200 W output power with the deposition rate of 19.5nm/min. These films were tested in thin film solar cells based on the absorber material Cu(In,Ga)S$_2$. Also, the laser scribing process was tested for such TiN films in order to prepare mini-modules.

Keywords
titanium nitride
solar cell
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