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Investigation of Atomic Layer Deposited Al-TiO_x as Passivating Contacts on Silicon Solar cells

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Transition metal oxide (TMO) layers have attracted significant interest recently in the photovoltaic community. TMOs can be used as a carrier selective passivating contact and have superior optical properties compared to doped poly and amorphous silicon. Atomic layer deposition (ALD) with its ultimate process control and low substrate temperature is a very appealing method for depositing these TMO layers. ALD titanium oxide (TiO_2) has been reported to be an excellent electron selective contact on silicon solar cells with a high level of surface passivation; however, its poor thermal stability[1][2] limits the the range of processes which can be used after the application of the TiO_2 film which is in particular a significant restriction for the metalisation step. Aluminium (Al) doped TiO_2 are reported to effectively improve perovskite solar cell performance especially in electric properties via creating defetcs due to the size discrepancy between Ti and Al atoms [3]; however, ALD doping materials have never been reported to be applied on silicon solar cells.

In this study, we successfully introduced Al in TiO_2 layers using an ALD supercycle approach. *In-situ* spectroscopic ellipsometry was used to assist in the optimisation of the ALD supercycle recipe. Al-TiO_2 layers grown with different Al-Ti ALD cycle ratios were investigated. Time-of-flight secondary ion mass spectrometry (ToF-SIMS) results revealed the distribution of Al in TiO_2 after annealing as shown in Figure 1. The presence of Al^{+3} and Ti^{4+} was detected in the film by X-ray photoelectron spectroscopy (XPS). XPS was also used to quantify the [Al] and [Ti]. As shown in Figure 2, a champion effective minority carrier lifetime of 1.9 ms is obtained from Al-TiO_2/SiO_2/*n*-Si stack after 300 ^oC annealing while a significant lower lifetime of 210 µs is obtained from the undoped reference. This indicates that Al incorporation increases the thermal stability of TiO_2 layer, and this is very beneficial from an application point of view. The contact resistance also reduces by introducing Al into, which can probably be attributed to the defect states introduced by Al.

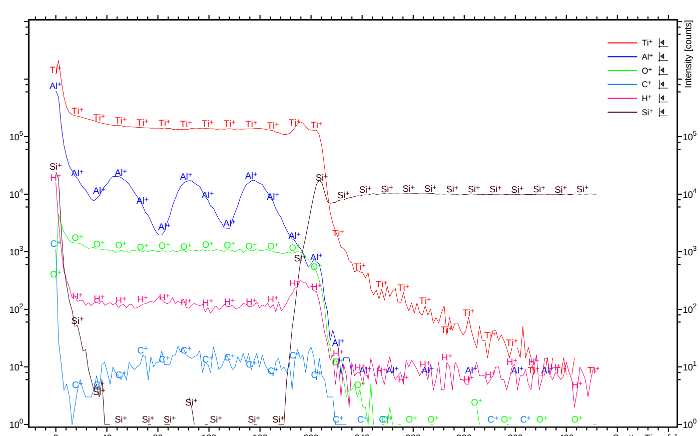

Figure 1 Tof-SIMS profile of Al-TiO_2 layer on c-Si after annealing at 250 ^oC (ALD cycle ratio 1:120).

In conclusion, we show that the introduction of Al in TiO_2 significantly improves its thermal stability and lowers the contact resistance allowing for higher post-processing temperatures which is very beneficial for e.g. the metallization step. Future work is going to focus on unraveling the underlying mechanisms behind the improved performance and the integration of these layers in silicon solar cells.

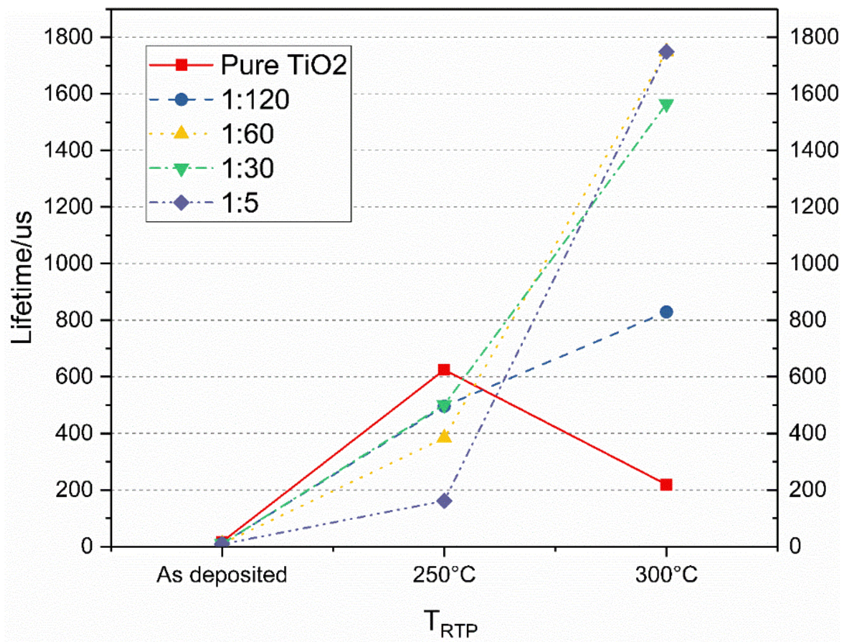

Figure 2 Effective lifetime as a function of post-deposition annealing temperature for of different doping ratio Al-TiO_2 films on *n*-type c-Si.

References

[1]Yang, X., Bi, Q., Ali, H., Davis, K., Schoenfeld, W.V. and Weber, K., 2016. High-performance TiO2-based electron-selective contacts for crystalline silicon solar cells. *Advanced materials*, *28*(28), pp.5891-5897.

[2]Matsui, T., Bivour, M., Ndione, P., Hettich, P. and Hermle, M., 2017. Investigation of atomic-layer-deposited TiOx as selective electron and hole contacts to crystalline silicon. *Energy Procedia*, *124*, pp.628-634.

[3]Liu, W., Zhang, L., Liao, L., Liu, Z., Wang, D., Chen, Q., 2016. Synthesis of Al-Doped TiO_2 Thin Films by Low Temperature Atomic Layer Deposition for Perovskite Solar Cells. *Chinese Joural of Vacuum Science and Tecnology*, 36(6), pp.705-709.