IMPACT OF PEDOT: PSS AND LIGHT SOAKING ON PASSIVATION PROPERTIES OF ULTRATHIN ATOMIC LAYER DEPOSITED TiO\textsubscript{x} LAYERS

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Ultrathin titanium oxide (TiO\textsubscript{x}) is known to be a successful dielectric material for its application as an electron selective passivated contact in a silicon based solar cell; using atomic layer deposited TiO\textsubscript{x} on rear side, solar cell efficiencies above 22\% have been achieved. Recently, silicon oxide (SiO\textsubscript{x})/poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) contacts have resulted in high efficiency of above 20\%, having the advantage of being a low temperature, low cost organic alternative to SiO\textsubscript{x}/poly-Si contacts. Substituting the SiO\textsubscript{x} tunnel layer by a SiO\textsubscript{x}/TiO\textsubscript{x} stack can further improve contact passivation properties. This is the motivation behind this work. Currently, there are very few reports on the passivation properties of ultrathin ALD TiO\textsubscript{x} films, but the impact of light illumination on the passivation properties of ultra-thin ALD TiO\textsubscript{x} capped with PEDOT:PSS remains unexplored. According to our initial findings, a correspondingly passivated lifetime sample shows even enhanced performance under solar illumination. Using ALD grown ultrathin TiO\textsubscript{x} layers (0.5 – 2 nm) on –OH terminated (SiO\textsubscript{x}), n-type c-Si Cz wafers, it was observed that the introduction of PEDOT: PSS layer increases the lifetime of SiO/0.5 nm thick TiO\textsubscript{x} by almost 70\% or even 171\% (under light soaking for 15 min) as shown in Figure 1(a). We performed these experiments on 1, 1.5 and 2 nm thick ALD TiO\textsubscript{x} coated with PEDOT:PSS and observed a similar trend. Interestingly, while a 15 min light soaking does not increase lifetime for uncapped SiO\textsubscript{x}/ALD TiO\textsubscript{x} layers, the observed 171\% increase of lifetime of PEDOT:PSS capped samples even increases after a subsequent storage in the dark, see Fig. 1b (top). This can be likely attributed to charge accumulation within the PEDOT:PSS layers, as an increase in lifetime for the capped samples is also observed without light soaking (dark storage only), see Fig. 1b (bottom). A longer light soaking (up to 5 days) will result in a similar lifetime increase for uncapped SiO\textsubscript{x}/ALD TiO\textsubscript{x} lifetime sample, but this increase is lost as soon as they are stored in the dark, see Fig. 1c. Thus, it is recommended to use the SiO\textsubscript{x}/TiO\textsubscript{x} tunnel layers in combination with some (PEDOT:PSS) capping layer. Further, microscopic and spectroscopic characterization is planned to correlate the electrical properties with structural properties/bonding configurations.

![Figure 1: Effective lifetime, $\tau_{\text{eff}}$ (measured at $\Delta n = 10^{15}$ cm$^{-3}$) for symmetrical lifetime samples (a) using 0.5 nm thick TiO\textsubscript{x}, TiO\textsubscript{x} capped with PEDOT:PSS, and TiO\textsubscript{x} capped with PEDOT:PSS and light soaked for 15 min. (b)-(c) illustrates comparison of no light soaking, 15 min and 5 day continuous light soaking of TiO\textsubscript{x} and TiO\textsubscript{x} capped with PEDOT:PSS samples for 0.5 nm thick TiO\textsubscript{x}. Please note that during dark storage samples were stored in a dry cabinet.](image-url)