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Sputtered MoOx Films: A Dopant-Free Approach to Passivation and Hole Selectivity in SHJ Solar Cells

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Nowadays, the c-Si Heterojunction (HJ) architecture stands out as one of the most widespread and efficient solar cell technologies. It is based on intrinsic a-Si interlayers to passivate surface defects on c-Si surface, while n- and p- doped a-Si layers serve as electron and hole selective contact. Nonetheless, this approach exhibits some drawbacks, that include parasitic optical losses, low band bending at the interface with the absorber layer, and the use of dangerous gases. A promising solution is the implementation of dopant-free passivating contacts, by using cost-effective and wide bandgap materials, with a proper work function and electronic band structure to selectively transport the desired type of charge carriers.
This work focuses on exploring strategies to replace (p) a-Si with sputer-deposited Molybdenum Oxide (MoOx) thin films. The goal is to improve hole selectivity and minimize carrier recombination. Achieving these objectives requires the optimization of material properties, involving both structure and interface engineering. Although improvements in External Quantum Efficiency (EQE) are recorded in solar cells using MoOx grown by evaporation, there is no evidence of good performance for films deposited by sputering, which is cheaper and already common in industrial flows. However, achieving a fine control over film stoichiometry poses a challenge in ensuring efficient hole selectivity and maintaining film stability within the HJ.
Ultra-thin amorphous MoOx films ($2<x\leq3$) are grown via RF magnetron sputering by a MoO3 target in an atmosphere of pure Ar or an Ar/O2 mixture. Differences in optical properties and electronic structures were identified through Spectrophotometry and X-ray Photoelectron Spectroscopy. The trade-off between film transparency and Mo5+ percentage, associated with O vacancies concentration, is demonstrated. Films grown in an Ar/O2 atmosphere exhibit higher transparency, a larger bandgap and a higher work function.
We carried out EQE measurements of HJs with different MoOx ultra-thin films instead of (p) a-Si. Our findings showcased an EQE improvement in the UV-Vis range. The best performances were obtained with MoOx deposited in an Ar/O2 atmosphere. We also characterized the Si/MoOx interface, which plays a fundamental role in surface passivation, and the stability of MoOx. We evaluated the ability of MoOx films to serve as passivating contacts. Our outcomes are encouraging for the elimination of the (i) a-Si layer as passivating contact, thereby reducing the optical losses in the UV range and improving EQE. These findings support sputering as a viable method to grow dopant-free passivating contacts for next-generation PV technologies.