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Next-Generation of Silicon Heterojunction Solar Cells: Using Transition Metal Oxide (TMOs)

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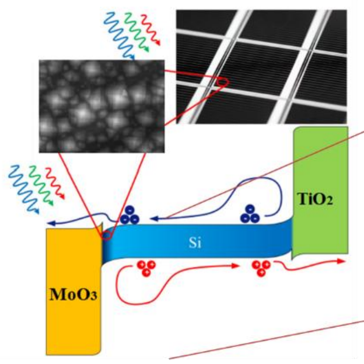
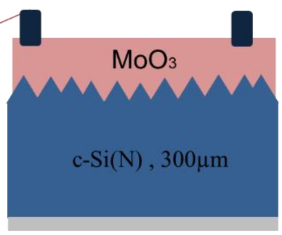
Abstract :

Dopant-free carrier-selective transition metal oxide (TMO) contacts exhibit unique electrical properties that effectively address doping-related challenges in n-type crystalline silicon (c-Si(n)) solar cells. In this study, we fabricated a c-Si(n) heterojunction solar cell incorporating TMOs specifically titanium oxide (TiO_x) and molybdenum oxide (MoO_x) as electron-selective and hole-selective contacts, respectively, under low-temperature conditions. The photovoltaic performance of the device was assessed by analyzing the optical and optoelectronic properties of the TiO_x and MoO_x thin films, as well as the interfacial charge density at the MoO_x/Si and Si/TiO_x junctions. Our results demonstrate that rapid thermal processing (RTP) annealing at temperatures ranging from 300 °C to 400 °C significantly reduces interfacial recombination, thereby enhancing electron transport. The fabricated device achieved promising values of open-circuit voltage (V_{oc}) and short-circuit current density (J_{sc}). These findings validate the potential of this heterojunction architecture, which features fully covered carrier-selective contacts, for industrial applications. The integration of TiO_x and MoO_x as dopant-free contacts offers a promising pathway toward the development of high-efficiency, low-cost silicon solar cells.

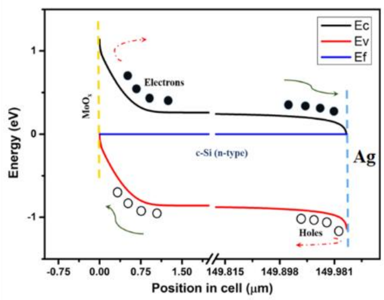
Results :



The solar cell structure was developed at the LPV Laboratory



MoO3/Silicon Heterostructure



Energy band diagram of the proposed device structure at equilibrium

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Conclusion:

This study confirms the effectiveness of dopant-free carrier-selective contacts based on transition metal oxides (TMOs) in enhancing the performance of n-type silicon heterojunction solar cells. The combined use of TiOx as an electron-selective contact and MoOx as a hole-selective contact, together with low-temperature rapid thermal processing, significantly reduced interfacial recombination and improved carrier transport. The promising photovoltaic results, particularly in terms of open-circuit voltage (Voc) and short-circuit current density (Jsc), highlight the strong potential of this heterojunction design for industrial applications. This approach offers a promising pathway for the development of high-efficiency, cost-effective, and sustainable silicon-based solar cells.

Références :

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