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Discovering Challenges in Fabrication of Nanostructured c-Si Solar Cells with Metal Oxides Carrier Selective Contacts

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A photovoltaic cell provides direct conversion of solar in to electrical energy. Most modern solar cells are based on silicon due to well-developed technology, high efficiency, and high reliability and relatively low cost. In this research, our approach is based on nano-texturing of the crystalline silicon (black c-Si) with reactive ion etching (RIE)¹ and KOH techniques, ALD deposition of titanium oxide (TiO₂)² and RF magnetron sputtering of nickel oxide (NiO) films as carrier selective contacts^{3,4}. Black c-Si technology allows reaching reflectivity below 1%. TiO₂ is a wide band gap semiconductor, transparent to photons with energy below 3.2 eV, it is a n-type electron selective layer. NiO is also wide bandgap (3.4 eV) p-type semiconductor, complementary to TiO₂, allowing only hole transport. Further fabrication process included RCA cleaning of nanostructured surfaces and deposition of Al₂O₃ passivating film with atomic layer deposition (ALD)⁵. In order to create local area carrier selective contacts, standard photolithography was used to make opening in Al₂O₃ film. 5 nm of TiO₂ film was deposited with ALD at 80°C. The second photolithography was applied form back contacts openings priory RF sputtering of Ni in O₂ and Ar plasma and NiO film deposition. Front contact grid was formed with the third photolithography and liftoff process. Both, front and back contacts were deposited with electron beam method with a thickness of 600 nm of Al.

In summary, characterization results of the fabricated cell helped to define a number of challenges:

- High surface damage during RIE process and therefore high recombination losses
- ALD Al₂O₃ process shows low passivation quality due possible low quality of TMA precursor.
- ALD TiO₂ films were deposited with TiCl₄ precursor, which is also lacking good passivation quality, TiO₂-Si form leaky diode due to interface defects and some Ti metal traces at the interface.
- NiO RF sputtering damages Si due to the nature of sputtering process. The stoichiometry of NiO film sputtered from Ni in O₂ and Ar plasma is not predictable and can be modified with a small parameters shift.
- Al electron beam deposition possibly damaging TiO₂ 5nm film, which leads to diode leakage

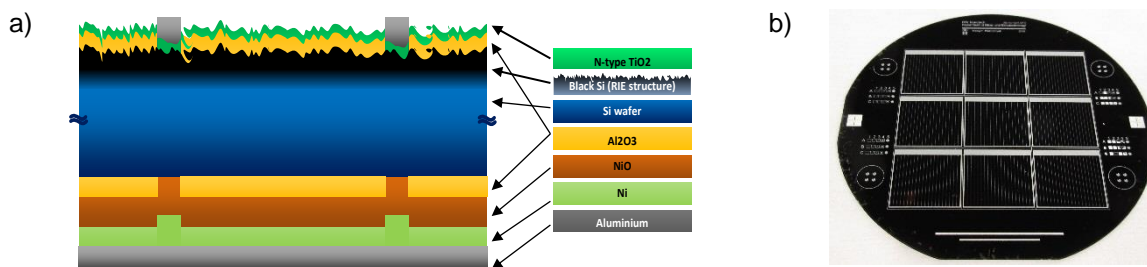


Figure 1. Nanostructured c-Si solar cells with metal oxide carrier selective contacts: a) cross-section schematics of the solar cell architecture, b) photo image of fabricated black silicon solar cells with carrier selective contacts

¹ M. Plakhotnyuk, et al. Lifetime of Nano-Structured Black Silicon for Photovoltaic Applications. 32nd European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC, 2016).

² M. Plakhotnyuk, et al. B. Abstr. DTU's Sustain Conf. 2015 E-37, 2 (2015).

³ S. Avasthi, W. McClain, J. Schwartz, and J.C. Sturm, in *70th Device Res. Conf.* (IEEE, 2012), pp. 93–94.

⁴ X. Yang, P. Zheng, Q. Bi, and K. Weber, *Sol. Energy Mater. Sol. Cells* **150**, 32 (2016).

⁵ B. Hoex, J. Schmidt, P. Pohl, M.C.M. van de Sanden, and W.M.M. Kessels, *J. Appl. Phys.* **104**, 44903 (2008).