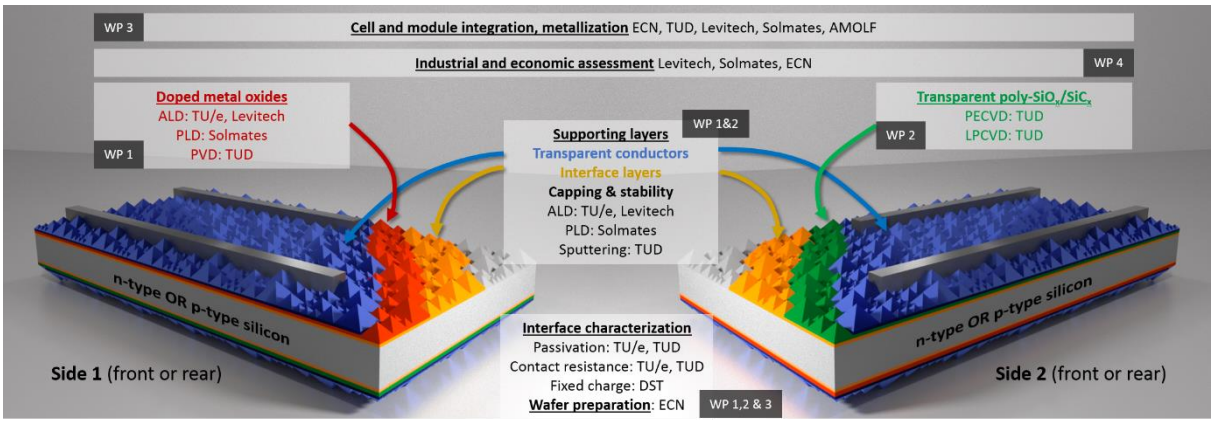
# Openbaar eindrapport TKI Urban Energy project RADAR

## Uitgangspunten en doelstellingen van project en partners

Within the last few years, there has been a strong focus in research and development on passivating contacts, both worldwide and in the Netherlands. Within various TKI projects the topic of passivating contacts, both based on poly-Si and transition metal oxides (TMOs), are being addressed. Although these passivating contacts can deliver high efficiency solar cells, the poly-Si based contacts are limited in transparency, whereas TMOs suffer from lower performance and thermal/chemical stability in the explored range. The goal of the RADAR project was, therefore, to develop new materials and solar cell manufacturing processes for high efficiency, bifacial solar cells with transparent passivating contacts, using two parallel approaches: (1) Start from transparent metal oxides, and make them more chemically stable by intentional doping and (2) Start from more chemically stable poly-Si contacts, and make them transparent by alloying with oxygen or carbon.




## Behaalde resultaten

The TU/e developed novel (doped) metal oxides by ALD for passivating contact applications. $Nb_2O_5$ was found as a novel passivating contact material, whereas conductive $ZnO/Al_2O_3$ and $PO_x/Al_2O_3$ *(patent pending)* were found to yield state-of-the-art passivation of $n^+$ surfaces, and are explored in follow-up projects. TUD developed more transparent O/C-alloyed poly-Si contacts and demonstrated a preliminary cell efficiency of 21.5%. SOLMATES developed PLD TCOs and selective TMOs. During consortium runs with ECN.TNO, the high compatibility of PLD was demonstrated by achieving an $iV_{oc}$ of 744 mV. The implementation of a thin $AlO_x$ interlayer below e-beam $MoO_x$ has led to a new moly-poly record of 18.2% for a 6 inch solar cell, made at ECN.TNO, that is thermally stable up to 230°C. Meanwhile, DST further developed their corona charging system (CCS), and successfully demonstrated its use for characterizing novel passivation schemes.

Cost calculations and a SWOT analysis, performed by Levitech and ECN.TNO, show the clear promise of TMO passivating contacts to yield solar cells at competitive costs compared to existing PERC(+) technology, which mainly stems from the lean processing aspect. At the same time, the analysis outlines a clear path for the further development of transparent passivating contacts, motivating the consortium to continue the momentum gained through the COMPASS and RADAR projects.

## Perspectief voor toepassing en spin-off

Wafer-based crystalline silicon PV technology is the dominant technology having a market share of over 90%, of which p-type PERC technology is the rising star. Silicon PV based on n-type wafers has the potential for higher efficiencies, because of its lower sensitivity to most common transition metal impurities and the absence of light-induced degradation. Because of the growing market, better economic opportunities and a rising demand for higher efficiencies, the market perspective for new technology will improve and create openings high efficiency technologies like the Moly-$TiO_x$ (MoTi) cells developed in this project. The whole market, from manufacturers to PV installing companies, from equipment vendors to engineering companies, and finally the end-user (consumers) will profit because of improved margins and lower LCoE. Dutch equipment suppliers will benefit even more, because of their better knowledge position.

Some more directly tangible follow-up results of this project are, for example:

- The $PO_xAlO_x$ stack is patented as a high potential surface passivation layer and research into the application of this step was integrated in follow-up/sister projects MIRACLE and BRIGHT. The same holds for the newly-developed conductive $ZnO/Al_2O_3$ passivation layers.
- The development of doped $SiO_x$ layers is continued in the TKI projects HT-SOHO and Saturnia.
- The collaboration between ECN.TNO and AMOLF has led to two guest researchers from ECN.TNO working part-time at TNO on the development of the solar cell with nanowire contacts. Very high efficiency solar cells are expected as a result from this collaboration on the short term.
- The development of PLD metal oxide layers for industrial solar cells has been picked up by ECN.TNO in collaboration with Solmates.

## Bijdrage van het project aan de doelstellingen van de TKI Urban Energy

The targets of the TKI Urban Energy are a sustainable infrastructure and a reinforcement of the knowledge position. The RADAR project has contributed towards reaching this goal through the generation of Dutch knowledge to lower the production costs of highly efficient solar cells through the simplification of production processes. This lowers the price of solar energy. Furthermore, in the context of the RADAR project, solutions have been found based on equipment that is being developed in the Netherlands, which reinforces both the knowledge position and the economy.

## Overzicht van openbaar verkrijgbare publicaties van RADAR resultaten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Meer exemplaren van dit rapport zijn verkrijgbaar via het secretariaat van ECN.TNO Solar Energy.

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