SMART INDUSTRIES

SNROOF

Solar multi-junction cells iNtegrated in 3D curved ROOFs of electric vehicles

The EU has set an ambitious target to reduce the CO2 emissions of new passenger cars by one-third by 2030. To achieve this goal, the transition from vehicles powered by fossil fuels to electric vehicles (EVs) will play a crucial role. But equally important is that the electricity used to power those EVs must also be low-emission and preferably coming from renewable energy sources.
Self-charging EVs that directly charge from the sun might solve all of these challenges at once. An obvious solution would be to use roof-mounted photovoltaics, as path that car manufacturers have started to pursue. The first self-charging passenger cars that have been commercialized, however, are still limited to power outputs that severely limit the achievable range and reduction in CO2 emissions. At the other end of the spectrum, one manufacturer recently demonstrated a cruising range of close to 45 km/day using extremely expensive solar cells made for space applications.
In sum, there are still many challenges to overcome before we will have EVs with photovoltaic cells that produce enough power, cover a limited surface, and don't compromise on looks and costs.

FRAMING THE RESEARCH OBJECTIVE

The imec.icon project SNRoof, a consortium of Flemish companies and research partners set about to finds solutions for this challenge. The objective was to develop a photovoltaic laminated glass sunroof with a power density of up to 200 Watt per m2, containing integrated photovoltaics with excellent aesthetics and improved tolerance to shading.
The SNRoof consortium consisted of 4 industrial partners (AGP eGlass, Arkema, IPTE, and MAM) with a strong track record in the automotive industry, and 4 research teams (IMOMEC, ESYSTEMS, PVCM, TFPV). Together, these partners' complementary expertise ranged from advanced cell technology all the way to system integration and modeling.

THREE MAIN OUTCOMES

The SNRoof consortium developed three generations of laminated panoramic sunroofs with integrated photovoltaics. The first generation reached power densities of more than 190 Watt per square meter using standard silicon solar cells and interconnection technologies. A second generation managed power densities over 210 W/m2 using more advanced silicon technologies. Finally, the third generation demonstrated the feasibility of achieving power densities over 230 W/m2 using novel perovskite/silicon tandem technology, albeit still on a small area using lab processes.
The partners also worked on novel module layouts to maximize the sunroof output. They tested and compared several concepts, both geometrical and electrical, to understand their impact on the energy yield: different sizes of solar cells, bypass diodes vs. optimizers, series vs. parallel connections of cell-strings, and finally innovative grouping of solar cells to avoid mismatches within the modules. Parallel connections and smart clustering of solar cells in cell strings allowed for a yield increase of up to 5%.
The third outcome concerns innovating the curved glass coatings and lamination technologies so that they meet all requirements,

including those set by the automotive industry for vehicle components.
A first challenge here was to come up with UV/IR resistant and scratch-resistant low-emissivity coating technologies adapted for curved sunroofs. Implementing all required characteristics at the same time (low-e property, transmission/color, coating adhesion, scratch resistance, low-e coating protection and roll-2-roll applicability) in a single topcoat is challenging. The partners tested and compared several concepts using e.g., PMMA, siloxane, parylene, or a base + topcoat. They demonstrated scratch-resistance, but haven't yet defined the one most ideal solution.
In parallel, the researchers developed a novel encapsulant compatible with automotive requirements and with Pk/Si tandem cells. They applied specific formulations to also address haze and adhesion properties, as well as compatibility with PVB glass. A preliminary testing with Pk/Si tandem cells, proved the compatibility of the encapsulant and lamination process with such cells.
The project's goal was to create PV sunroofs of over 1 m2 with a thickness of 6.1 mm. That goal was achieved through a double-membrane lamination that allowed to successfully laminate several demonstrator sunroofs with double curvature, using a glass- glass configuration with 4 layers of encapsulant.

NEXT STEPS

The results of the Sunroof project are generic and the partners foresee valorizing the solutions and technologies (coating, encapsulant, low temperature soldering, multi-wire solution, curved glass...) both collectively and individually.
The SNRoof R&D will help AGP to stay at the forefront of automotive glazing innovations. AGP has therefore already defined a valorization business plan. IPTE, MAM, and Arkema plan to valorize the technologies both collectively through AGP, but also individually and for other applications than sunroofs. The progress made by IPTE on the foil making equipment and by Arkema on the adapted POE foil material and encapsulant is generating strong commercial interest in other applications such as integrated PV applications, e.g. building-integrated PV. Finally, MAM's results on glass coating technologies has a high potential for valorization for all applications for which solar control is key (UV/IR cut-of, low emissivity, anti-reflective coating).

SNRoof project partners:

The SNRoof project was co-funded by imec, with project support from Agentschap Innoveren & Ondernemen

FACTS

NAME	**SNROOF**
OBJECTIVE	Develop an efficient, reliable, high power-density, and cost-competitive integrated photovoltaic sunroof for electric vehicles
TECHNOLOGIES USED	Electric vehicles, integrated photovoltaics, perovskites, laminated photovoltaics, photovoltaic interconnections
TYPE	imec.icon project
DURATION	01/10/2020 – 30/09/2022
PROJECT LEAD	Francis Steyaert, Soliver
RESEARCH LEAD	Hariharsudan Sivaramakrishnan Radhakrishnan, imec – PVCM
BUDGET	3,211,877.72 euro
PROJECT PARTNERS	Soliver, IPTE Factory Automation, Arkema France SA, Michiels Advanced Materials
RESEARCH PARTNERS	-
RESEARCH GROUPS	imec – PVCM, imec – IMO – IMOMEC, imec – TFPV, imec – Energy Systems

WHAT IS AN
IMEC.ICON PROJECT?

The imec.icon research program equals demand-driven, cooperative research. The driving force behind imec.icon projects are multidisciplinary teams of imec researchers, industry partners and/or social-profit organizations. Together, they lay the foundation of digital solutions which find their way into the product portfolios of the participating partners.

CONTACT US
WWW.CONTACTIMEC.COM