

PRESS RELEASE

Solliance tops 21.5% efficiency with a flexible Perovskite-CIGS tandem

Eindhoven (Netherlands) – 29 January 2019 – Scientists at Solliance, in collaboration with MiaSole Hi-Tech Corp., fabricated a flexible solar cell with a record breaking power conversion efficiency of 21.5%. The solar cell combines two thin-film solar cell technologies into a 4 terminal tandem solar cell stack: a top flexible semi-transparent perovskite solar cell with a bottom flexible copper indium gallium selenide (CIGS) cell.

A tandem solar cell, which combines a perovskite and a Cu(In,Ga)Se₂ (CIGS) cell, has the potential for high conversion efficiency exceeding single junction solar cell performance thanks to tunable and complementary bandgaps of these individual thin film solar cells. CIGS technology has a proven track record as a high efficiency and stable solar technology, and has entered high volume manufacturing in multi-GW scale around the world. CIGS technology has been successfully used to produce high efficiency flexible and lightweight cells and modules, which address markets where heavy and rigid panels cannot be used. Perovskite solar cells, despite being a relatively young technology, have already achieved high efficiencies, and promise low cost solar technology based on abundant materials. Combining both technologies in a flexible and lightweight package expands the horizon of high performance, flexible, and customizable solar technology.

In order to realize maximum conversion efficiencies, the absorption properties of the top perovskite cell and of the bottom CIGS cell should be tuned to complement each other. The perovskite solar cell was deposited on a transparent and flexible substrate, employed transparent conductive electrodes, and was optimized for maximum visible light conversion efficiency and infrared light transparency to allow the majority of infrared light to reach the bottom CIGS cell.

The CIGS bottom cell was developed by MiaSolé Hi-Tech, a provider of CIGS production turn-key factories and manufacturer of CIGS flexible solar panels, located in Silicon Valley, California. The CIGS cell is based on a commercially available high efficiency flexible solar cell technology fabricated on lightweight stainless-steel foil using a proprietary high throughput roll-to-cell sputtering process. Properties of the bottom cell were optimized to match the top cell light transmittance spectrum to achieve high tandem cell performance.

As result of combined expertise of MiaSolé Hi-Tech in the area of CIGS development and manufacturing, and the expertise of the Solliance team in the area of perovskite technology a new record efficiency flexible perovskite/CIGS tandem cell was produced. "Optimizing the bandgap of both cells was an important step in achieving this result", according to Mehrdad Najafi, Researcher at Solliance Solar Research, "These results are very promising for further development of high efficiency flexible solar modules".

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Program Manager of the Solliance Module Technology Program Hans Linden states: "This tandem development is a perfect example of the added value of working closely together on seemingly different technologies. Building a strong relationship and establishing trust between Solliance and MiaSolé enabled high level of cooperation, and made this progress possible. Next step is to further increase efficiency and, more importantly, to scale this technology to commercial-size cells and modules."

"As single junction efficiencies get closer to the theoretical limits, improving module performance while continuously reducing \$/W costs becomes more difficult", adds Director of Technology at MiaSolé Hi-Tech Dmitry Poplavskyy, "We believe that combining our core CIGS technology with a low-cost perovskite technology in a tandem architecture will allow us to achieve high module efficiencies while maintaining low \$/W costs".

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About Solliance Solar Research

Solliance is public-private partnership of companies, R&D institutes and universities from the Netherlands, Belgium and Germany, working in thin film photovoltaic solar energy and led by imec and TNO. In order to strengthen the region's position as a world player in PV, Solliance is creating the required synergy by consolidating and coordinating the activities of 250 researchers in industry, at research institutes and universities.

Various state-of-the-art laboratories and pilot production lines are jointly used for dedicated research programs which are executed in close cooperation with the solar business community.

Solliance offers participation in its research programs and opens up its lab facilities to new entrants, either from industry or in research. On the basis of clear Intellectual Property (IP) agreements, each industrial partner can participate in this research effort, or alternatively, hire equipment and experts to further develop its own technology.

About MiaSolé Hi-Tech

MiaSolé- Hi Tech is a producer of lightweight, flexible and powerful solar cells and cell manufacturing equipment. The innovative solar cell is based on the highest efficiency thin film technology available today, and its flexible cell architecture makes it ideal for a wide variety of solutions ranging from commercial roofing solar panels to flexible mobile energy devices. MiaSolé's turnkey CIGS equipment lines, CIGS process equipment technology, proprietary CIG target manufacturing, R&D support and spare parts allow customers to produce their own high-efficiency cells.

Founded in 2004, MiaSolé has evolved from a scrappy, Silicon Valley start-up to the world leader in thin film solar panel efficiency. In our Sunnyvale, CA facility, we have demonstrated 17.5% module efficiency in production and 19.4% cell efficiency in the lab.

In December 2012, MiaSolé became a member of the Hanergy family. Since then, MiaSolé joined the newly created Hanergy Solar Group as MiaSolé Hi-Tech Corp. Hanergy provides unparalleled financial, technical, and sales expertise.

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MiaSolé continues to increase cell performance as well as develop new applications for our technology. As part of the Hanergy family, we continue to be on the forefront of the solar industry, with over 200 invention patents and patent applications worldwide.

About imec

Imec is a world-leading research and innovation hub in nanoelectronics and digital technologies. The combination of our widely acclaimed leadership in microchip technology and profound software and ICT expertise is what makes us unique. By leveraging our world-class infrastructure and local and global ecosystem of partners across a multitude of industries, we create groundbreaking innovation in application domains such as healthcare, smart cities and mobility, logistics and manufacturing, energy and education.

As a trusted partner for companies, start-ups and universities we bring together more than 4,000 brilliant minds from over 85 nationalities. Imec is headquartered in Leuven, Belgium and has distributed R&D groups at a number of Flemish universities, in the Netherlands, Taiwan, USA, China, and offices in India and Japan. In 2017, imec's revenue (P&L) totaled 546 million euro. Further information on imec can be found at www.imec-int.com.

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About TNO

TNO is an independent research organization of the Netherlands and connects people and knowledge to create innovations that boost the competitive strength of industry and the well-being of society in a sustainable way. This is our mission and it is what drives us, the over 3,200 professionals at TNO, in our work every day. We believe in the joint creation of economic and social value and we work in collaboration with partners and focus on different domains: 1- Buildings, Infrastructure & Maritime : 'Robust constructions, sustainable use', 2- The Circular Economy and the Environment: 'Directing and accelerating sustainability', 3- Defense, Safety and Security: 'We're putting our knowledge and technology to work for safety and security', 4- Energy: 'Faster towards a sustainable energy supply', 5- Healthy living: 'Focusing on participation, not on the disease', 6- Industry: 'Innovating for employment, welfare and well-being', 7- Information & Communication Technology: 'Interpreting and accelerating digital transformation', 8- Strategic Analysis & Policy: 'Turning complex issues into concrete innovations', 9- Traffic and Transport: 'Helping to create live able, sustainable cities'. Innovation with purpose is what TNO stands for. We develop knowledge not for its own sake, but for practical application.