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Press Release

43.6 % Four-Junction Solar Cell under Concentrated Sunlight

New Manufacturing Technologies allow for Higher Efficiencies

Freiburg, May 22, 2013 In an ambitious industry project with the French company Soitec, Fraunhofer ISE is currently developing a new generation of multi-junction solar cells with efficiency potential as high as 50 % under concentrated sunlight. For this, the researchers are replacing the conventional triple-junction solar cell – which consists of semiconductors from groups III and V of the periodic system – by a new four-junction device. Two dual-junction cell structures are first grown on separate III-V compound semiconductor substrates and then fused together so efficiently that the interface promotes the current flow through the four-junction solar cell device. Multi-junction solar cells are used in concentrator PV power plants.

"We are very pleased about the success of a 43.6 % cell which we were able to reach due to the wafer bonding technology. For the first time, we can combine the best III-V compound materials in one solar cell device. This leads us into a new generation of multi-junction solar cells showing outstanding efficiency potential," says Dr. Frank Dimroth, Department Head of III-V Epitaxy and Solar Cells at Fraunhofer ISE in Freiburg, Germany. "Now we are able to combine lattice mismatched crystals which with conventional technology cannot be grown on top of each other without deteriorating material quality." Wafer bonding refers to a technology where two different semiconductor crystals are brought into close contact to each other and compressed to form covalent bonds at the interface. This technology is a key expertise of the French company Soitec and the development partner CEA-Leti. It has been used for decades in manufacturing engineered substrates for the

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microelectronics industry. Soitec and CEA-Leti together have been successful in adapting the processes to meet the specific requirements of solar cells. These are namely mechanical stability, optical transparency and electrical conductivity of the bond interface.

At Fraunhofer ISE, more than 30 individual semiconductor layers had to be engineered and optimized for the new four-junction solar cell. Part of the cell structure was developed at the Helmholtz Zentrum Berlin in the research group of Prof. Thomas Hannappel, (now with Technical University Ilmenau) and transferred to Fraunhofer ISE where it was integrated into the epitaxy process.

The result of this French-German collaboration is a four-junction solar cell device with an outstanding efficiency of 43.6 % at a concentration level of 319 suns. The efficiency remains above 43 % in a concentration range of 250-500 suns. It is the first time that such a high efficiency is obtained for a solar cell with four pn-junctions in series. The further development of this new four-junction solar cell offers the opportunity to improve conversion efficiencies even further to 50 % in the future.

The application for these high efficiency multi-junction solar cells is primarily in photovoltaic concentrator modules of the company Soitec. In 2009, the company acquired the former Concentrix Solar GmbH, a spin-off from Fraunhofer ISE. Since then, Fraunhofer ISE continues to support Soitec in the development of high efficiency solar cells and point-focus concentrator PV modules. This technology is used worldwide in solar power plants in regions with high solar irradiance.

"Concentrator photovoltaics constantly improves in conversion efficiency and therefore lowers area-related costs," says Prof. Eicke Weber, Director of Fraunhofer ISE. "The new solar cells with their new process technology and outstanding efficiency potential will make an important

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contribution to the success of concentrator photovoltaics. We are proud to perform this development with the company Soitec."

The French-German cooperation between Fraunhofer ISE, CEA-Leti and Soitec started with the Fraunhofer-Carnot project "SolarBond", funded by the French Agence Nationale de la Recherche ANR and the German Ministry of Research BMBF between 2009 and 2011. In this project, the partners demonstrated for the first time the successful transfer of ultra-thin solar cell layer structures and the application of re-usable engineered substrates. This was an important milestone on the way to a commercialization of the new four-junction solar cell. The achievements had been honored by the Franco-German Business Award in 2011.

About Fraunhofer ISE
With a staff of 1300, the Fraunhofer Institute for Solar Energy Systems ISE, based in Freiburg, is the largest solar energy research institute in Europe. Fraunhofer ISE is committed to promoting energy supply systems which are sustainable, economic, safe and socially just. It creates the technological foundations for supplying energy efficiently and on an environmentally sound basis in industrialized, threshold and developing countries. To this end, the institute develops materials, components, systems and processes for a total of eight different business areas: Energy-Efficient Buildings, Applied Optics and Functional Surfaces, Solar Thermal Technology, Silicon Photovoltaics, Photovoltaic Modules and Systems, Alternative Photovoltaic Technology, Renewable Power Supply and Hydrogen Technology. Fraunhofer ISE also has numerous accredited test facilities. For more information, visit www.ise.fraunhofer.de

About Soitec
Soitec is an international manufacturing company, a world leader in generating and manufacturing revolutionary

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semiconductor materials at the frontier of the most exciting energy and electronic challenges. Soitec's products include substrates for microelectronics (most notably SOI: Silicon-on-Insulator) and concentrator photovoltaic systems (CPV). The company's core technologies are Smart Cut™, Smart Stacking™ and Concentrix™, as well as expertise in epitaxy. Applications include consumer and mobile electronics, microelectronics-driven IT, telecommunications, automotive electronics, lighting products and large-scale solar power plants. Soitec has manufacturing plants and R&D centers in France, Singapore, Germany and the United States. For more information, visit: www.soitec.com.

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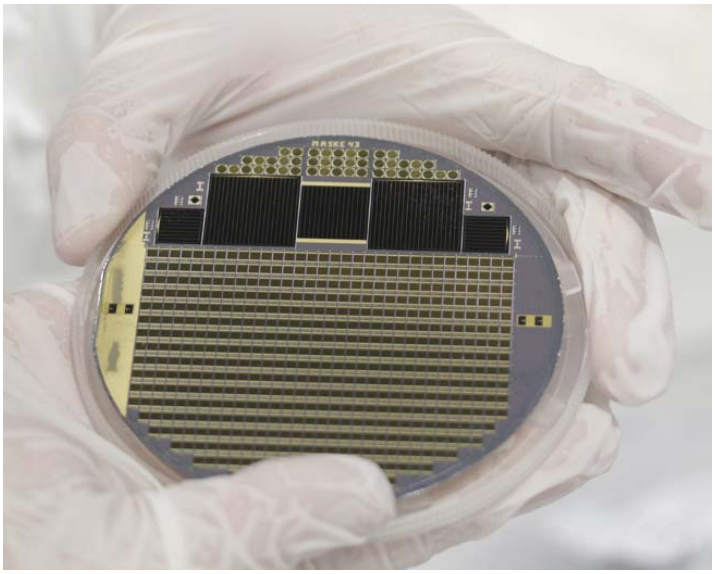
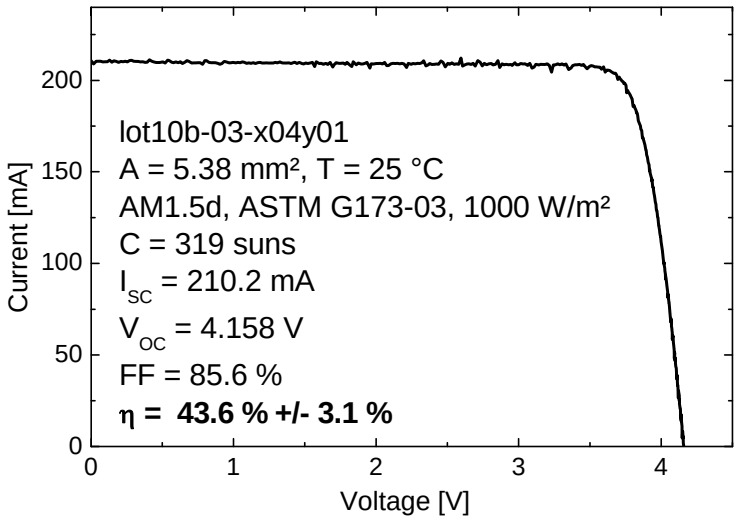


Image of a solar cell wafer with four-junction concentrator cells and test structures. ©Fraunhofer ISE



IV-characteristics of the currently best four-junction solar cell under the AM1.5d ASTM G173-03 spectrum at a concentration ration of 319 suns. The measurement was performed at the Fraunhofer ISE CalLab. ©Fraunhofer ISE

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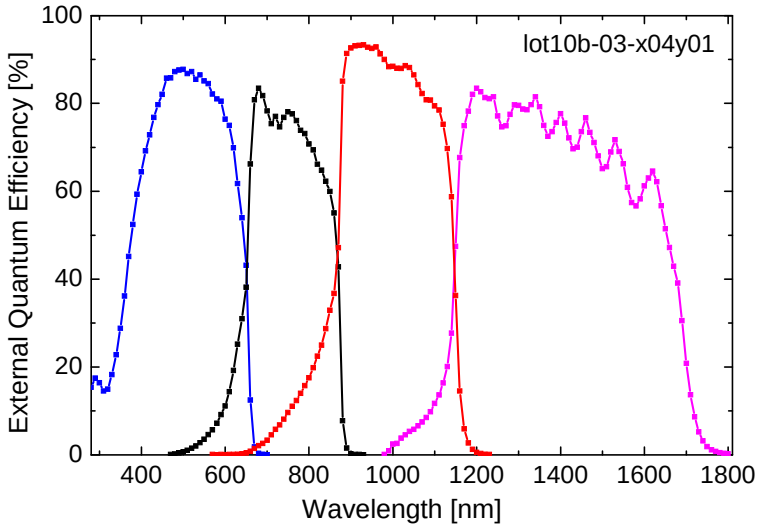

External Quantum Efficiency of the four-junction solar cell. The measurement was performed at the Fraunhofer ISE CalLab. ©Fraunhofer ISE

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