"Generating electrical power by direct conversion of light has the potential to be the answer to the top challenge of the 21st century."

A top challenge of the 21st century is to sustainably produce enough clean energy. Solar energy may be the answer. It can cover a substantial part of the future energy needs, even if the energy demand increases by a factor of 3 in the coming decades.

IMEC is uniquely placed to advance photovoltaic technology. It has a world-leading expertise in semiconductor physics and processing, extensive capabilities in device and material characterization, and a unique R&D infrastructure..

IMEC investigates several advanced and disruptive photovoltaic technologies in its unique processing infrastructure, with the ultimate aim of enabling **sustainable and affordable electrical power.**

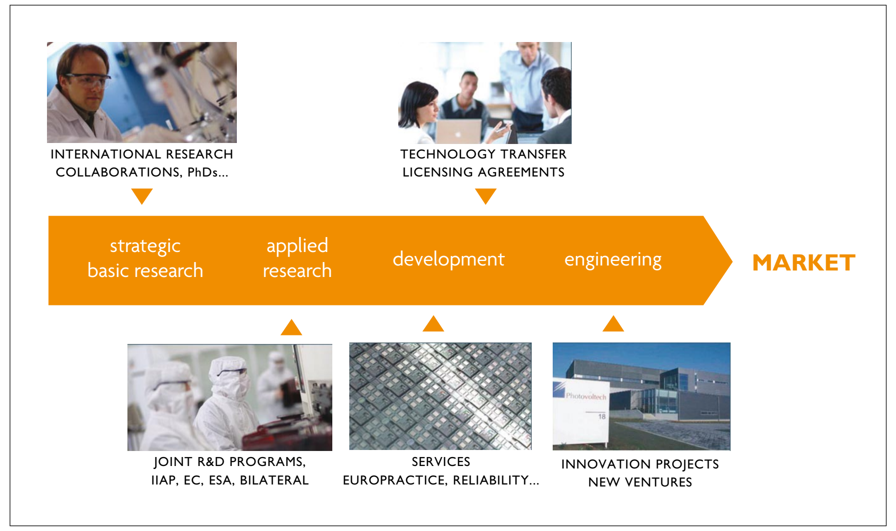
IMEC photovoltaic technology:

- Highly efficient thin crystalline Si solar cells
- Thin-film crystalline Si solar cells
- Organic solar cells
- Efficient photovoltaic stacks for solar concentration
- Thermophotovoltaic cells for co-generation

For:

- Sustainable and low-cost generation of energy
- Fully autonomous ambient-intelligence devices
- Energy generation for satellites
- Efficient energy generation with solar concentrators

Partner with IMEC for solar-cell research



IMEC is an independent research center, carrying out R&D programs in which companies, universities and other research institutes can participate. IMEC has dedicated cooperation schemes that are **tuned to the needs of the industry.** IMEC is bridging the gap between proof-of-concept in the lab and industrial manufacturing.

Why IMEC invests in photovoltaics

"There is broad consensus that solar energy has the potential to meet the growing demand for sustainable energy. In the past decade, the photovoltaic industry has strongly expanded and this breathtaking growth is expected to continue for another three decades. But to ensure economical viability, the cost of solar cells has to come down by at least a factor of 4. This calls for breakthrough photovoltaic technology, a domain in which IMEC is committed to play a leading role."

Prof. Dr. ir. J. Poortmans, Program Director SOLAR+

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HARVESTING THE SUN'S ENERGY

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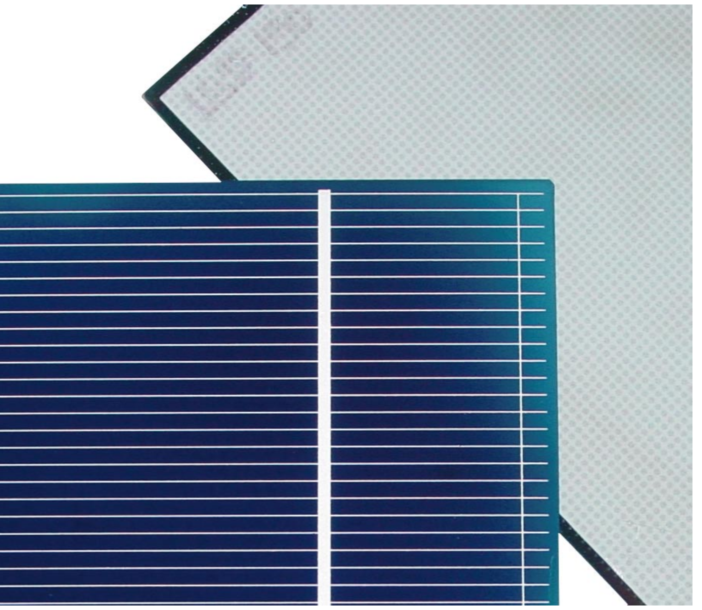
"The world energy demand will increase by a factor of 2 to 3 before 2050."

Highly efficient thin crystalline-silicon solar cells



Multicrystalline solar cell. On the right, the dots of the local contact scheme are visible.

ASPIRE

Crystalline Si solar cells are the workhorse of the photovoltaic industry, having a market share of more than 90% of the world production of solar cells. IMEC aims to reduce both the cost of producing crystalline Si solar cells, and the amount of Si/Watt that is needed.

INVENT

IMEC is following an ambitious roadmap towards using thin silicon wafers, while at the same time retaining the high efficiencies and manufacturability of the solar cells. The target is to reach an efficiency of 19% for 120μm multicrystalline Si, in an industrial process.

To produce even thinner foils of silicon, IMEC is working on innovative methods, such as a stress-induced lift-off technique.

ACHIEVE

IMEC has developed a very thin solar cell with dielectric passivation, using local contacts to replace the traditional full-aluminum back-surface field. IMEC's process flow combines industrial compatibility with the efficiency potential of laboratory solar cells. With wafers thinned down to below 140μm, open-circuit voltages remain high. And there is no wafer bending, even for substrates as thin as 80μm.

Thin-film crystalline-silicon solar cells

ASPIRE

To reduce the amount of silicon used, another approach is to form a thin film of active silicon on top of a low-cost substrate. The challenge is to find an optimal combination of cell efficiency, manufacturing cost, and large-scale production.

INVENT

IMEC is developing three thin-film approaches:

Epitaxial thin-film solar cells

On low-cost highly-doped crystalline-silicon wafers, an epitaxial active layer is deposited with a buried porous silicon reflector between the layers.

Thin-film solar cells based on layer transfer

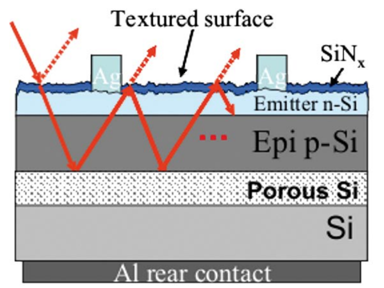
A thin layer of high-quality crystalline silicon is peeled from a parent substrate. The aim is to do this repeatedly, so that the final wafer cost per solar cell is low. IMEC is looking at various layer transfer methods, both with and without epitaxy.

Thin-film polysilicon solar cells

A layer of only a few μm of crystalline silicon is deposited on a low-cost substrate. IMEC is using thermal chemical-vapor deposition (CVD) on a heat-resistant substrate such as a ceramic or high-temperature glass covered with a seed layer.

ACHIEVE

For the three approaches, IMEC has produced promising cells with excellent efficiencies.



Epicell with buried reflector **based on porous Si.**

High-efficiency single-junction GaAs solar cell on Ge substrate.

Efficient photovoltaic stacks for solar concentration

ASPIRE

IMEC works on an innovative technology to produce mechanical stacks of solar cells made of different semiconductors. The semiconductors are carefully chosen to absorb nearly the entire solar spectrum. The resulting stacks will be capable of efficiencies of 35-40%, and will be used in earth-based solar concentrators and in satellites. The challenge is to find a cost-optimum between higher efficiencies and higher material and processing costs.

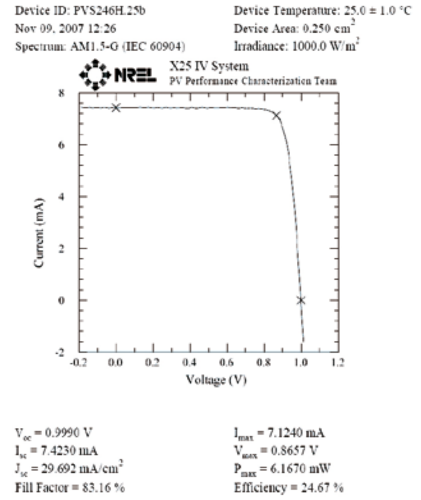
INVENT

IMEC's R&D focus is on stacked cells with III-V top cells and Ge bottom cells. Current research involves, among others, epitaxially growing single-junction GaAs and dual-junction InGaP/GaAs solar cells on Ge substrates using an improved manufacturing technology.

Next to further developing individual top and bottom cells, IMEC is optimizing the process of stacking the top and bottom cells, and of handling the thinned-down top cells.

ACHIEVE

IMEC's single-junction GaAs solar cell on a Ge substrate has reached a new world record conversion efficiency of 24.7%.



Performance characterization of IMEC's GaAs cell, measured by NREL.

Organic solar cells

ASPIRE

Organic solar cells have the potential to achieve a cost below 0.5euro/Wp because of the small quantities of molecules needed, and the possibility of using fast, in-line processes. IMEC aspires to increase the efficiency and lifetime of such solar cells, in the meantime developing a manufacturing technology for all layers of organic monolithic modules.

INVENT

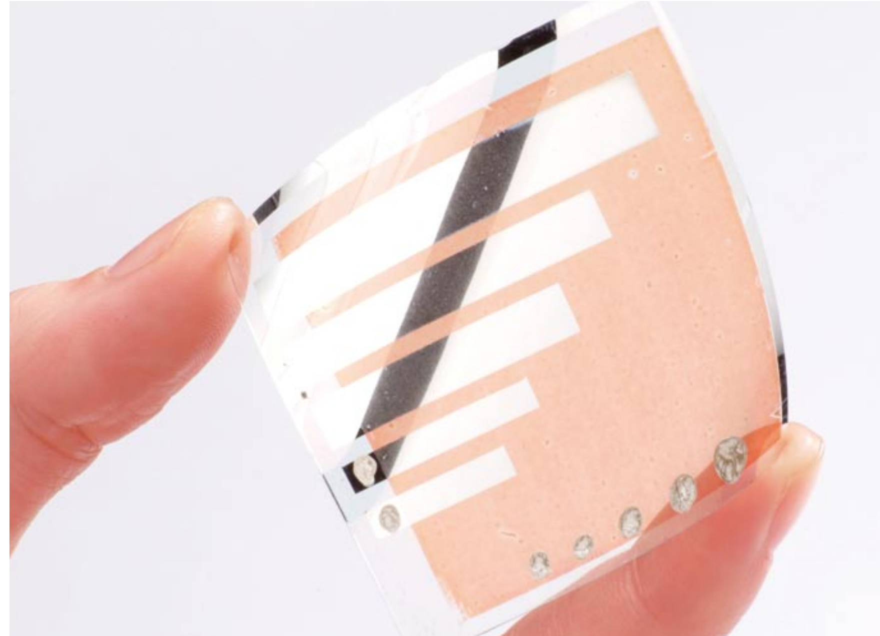
IMEC is looking to improve the cell efficiency by using novel low-bandgap materials and by building multi-junction stacks. The aim is to develop organic multi-junction devices with efficiencies over 10%. Active layers based on poly-thiophene are deposited by cost-efficient techniques such as inkjet printing and spray coating. And the evaporation of active layers with phthalocyanine materials is extended to low-vacuum technologies with high throughput.

Single cells are stacked by either thin metallic recombination layers or by ZnO-based intermediate contacts. Combining layers, processed from solutions or evaporated, results in complementary absorption in multi-junction stacks. To reach an operational lifetime of over 5 years for the solar cells, IMEC is working on active-layer nanomorphology stabilization and transparent barrier coatings.

ACHIEVE

IMEC has made solar cells with world-class efficiency: near 5% for poly(3-hexyl thiophene)-based cells, and over 3% for subphthalocyanine-based solar cells. IMEC also fabricated monolithic photovoltaic modules with up to 5 interconnected cells, processed with polymer solutions on flexible substrates. And tandem structures showing an improved open-circuit voltage have been demonstrated for both solution-processed and evaporated layers.

Polymer-based organic solar cells on a 5x5cm flexible substrate with an active layer deposited by screen printing.



Thermophotovoltaic cells for co-generation

ASPIRE

Thermophotovoltaic cells convert the radiation from heat sources that have a lower temperature than the sun. This calls for the use of materials with a lower bandgap than silicon. Worldwide, low-bandgap III-V compounds have been investigated for this purpose. IMEC has the ambition to further improve this technology by using high-efficiency, low-bandgap Ge cells to produce thermophotovoltaic cells that are highly efficient and stable under high fluxes of infrared radiation.

INVENT

IMEC is exploring the use of low-bandgap, stand-alone Ge solar cells with well-passivated surfaces and a highly reflecting rear side with laser-fired contacts. Synergies with IMEC's silicon solar-cell expertise have led to substantial progress.

ACHIEVE

With an improved surface passivation and novel contacting technologies, IMEC has produced Ge cells with an open-circuit voltage over 270mV and an AM1.5 efficiency of over 8%. The process is to a large extent compatible with silicon solar-cell processing.

IMEC also demonstrated improved quantum efficiency at wavelengths near the cell's bandgap by the use of a $Si/SiO_2/Al$ stack at the rear side.

Pilot line for solar cells

IMEC has set up the solar-cell pilot line to develop and refine solar-cell processes until they are ready to be transferred to production lines. The equipment is similar to that of a solar-cell production environment. And the batch size is large enough to allow valid predictions of averages, standard variations, and yield.

Techniques used in the pilot line include, among others, isotropic acidic texturing, plasma texturing, reduced pressure $POCl_3$ diffusion, large-area PECVD deposition of silicon nitride, and belt furnace rapid thermal anneal.

The pilot line is compatible with square wafers up to 15.6x15.6cm².