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Metal-organics hold key to EU's III-V solar push

An ambitious European project is expected to result in both a new material deposition system and higher-efficiency solar cells for concentrating photovoltaics.

Novel metal-organic sources of germanium and silicon could hold the key to a new generation of multi-junction solar cells, and ultimately to much cheaper solar energy production in sunny climates.

Researchers leading the European drive towards commercialization of concentrating photovoltaics (CPV) systems believe that growing germanium epilayers in these cells will represent a crucial step in the development of the technology.

In fact, the five-year, €11.7 million ($15.3 million) project that they are working under - dubbed "APOLLON" - represents the biggest single photovoltaics research effort funded through the European Union's Seventh Research Framework Programme (FP7) to date.

Gianluca Timò, who is co-ordinating APOLLON from the Italian research institute CESI Ricerca, has hailed the initial meeting between the 16 project partners – held in Cyprus last October – as a great success.

Powerful idea

"There is nothing more powerful than an idea whose time has come," he wrote in a letter to project collaborators following the Cyprus meeting, adding that now was the time for rapid innovation in CPV technology.

The ambitious objective set for the APOLLON collaboration, which includes MOCVD reactor company Aixtron, is to develop CPV systems at a cost of €2 per Watt of electricity produced.

To achieve that goal will require improvements to cell efficiencies, production yields and concentrator optics, but Timò believes that a successful outcome will see CPV become a key energy technology in the future.

The Italian researcher told *compoundsemiconductor.net* that the wealth of experience of people involved in the project – some have been working on multi-junction cells for more than 20 years – will see a great deal of support for the official cell supplier for APOLLON, Belgium-based Energies Nouvelles et Environment (ENE).

Timò adds that despite the recent progress made by US companies Spectrolab and Emcore in multi-junction cell efficiencies, it is crucial that growth techniques continue to be adapted to further improve cell performance.

As a result, one of the new ideas being worked on under APOLLON is to grow new materials with a 1 eV bandgap, possibly using epitaxial germanium alloys instead of InGaNAs layers to improve quantum efficiencies.

Diffusion penalty

And although the most efficient III-V cells on the market today rely on a diffused germanium junction, or InGaAs bottom cell, Timò believes that they can be improved by producing the germanium sub-cell in a different way.

"So far, InGaP/InGaAs/Ge structures have been realized with only the top and middle junctions epitaxially grown, while the third junction has been formed by atom diffusion into the germanium substrate," he explained.

According to the researcher, this process penalizes the third junction, since the dopant profile in the germanium lacks precision. This in turn leads to a high surface recombination velocity at the interface between germanium and the first nucleation layer – ultimately limiting cell performance.

Under APOLLON, the plan is to realize the very first InGaP/InGaAs/Ge structures in which each element of the cell is grown epitaxially.

Germanium epi

Crucial to enabling this approach has been the relatively recent development of the metal-organic material iso-butylgermanium, an innovation that may also lead to the first quadruple-junction InGaP/InGaAs/Ge-alloy/Ge solar cells.

Germanium epitaxy will also be pursued in a bid to grow III-V cells on top of a low-cost silicon substrate. Until now, research teams have approached the inevitable lattice-mismatch problem by using plasma-enhanced CVD to create SiGe alloys on top of silicon, before loading these 'virtual' substrates into an MOCVD reactor for subsequent III-V growth.

But under APOLLON, Timò and his collaborators will attempt to grow both SiGe and III-V epilayers by MOCVD, exploiting new silicon precursors that decompose at lower temperatures than conventional sources.

The first major project milestone will be to make sure that the germanium precursor does not impact subsequent III-V cell growth carried out in the same chamber – an effect that Timò refers to as autodoping.

Finding suitable buffer layers should achieve this aim, and if silicon substrates are found to be compatible with multi-junction cells, this approach may turn out to be a significant step on the road to CPV commercialization.

• The APOLLON (multi-APprOach for high-efficiency integrated and inteLLigent cOncentrating PV modules) project started officially on July 1, 2008. For further details of project partners and their aims, visit the official APOLLON site here.