Lowering cost of gallium arsenide for solar cells

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Through the use of a multilayer technique, researchers at the University of Illinois claim to have developed a more efficient, lower-cost method of manufacturing compound semiconductors such as gallium arsenide.

Professors John Rogers and Xiuling Li lead a team that explored lower-cost ways to manufacture thin films of gallium arsenide that also allowed versatility in the types of devices they could be incorporated into. The research is particularly targeted at photovoltaic cells, as gallium arsenide and related compound semiconductors offer nearly twice the efficiency as silicon in solar devices, yet are rarely used in utility-scale applications because of their high manufacturing cost, the university said.

"If you can reduce substantially the cost of gallium arsenide and other compound semiconductors, then you could expand their range of applications," said Rogers, the Lee J Flory Founder Chair in Engineering Innovation and a professor of materials science and engineering and of chemistry, in a statement.

The university explained that typically gallium arsenide is deposited in a single thin layer on a small wafer. Either the desired device is made directly on the wafer, or the semiconductor-coated wafer is cut up into chips of the desired size. The researchers decided to deposit multiple layers of the material on a single wafer, creating a layered, "pancake" stack of gallium arsenide thin films.

"If you grow 10 layers in one growth, you only have to load the wafer one time," said Li, a professor of electrical and computer engineering, in the statement. "If you do this in 10 growths, loading and unloading with temperature ramp-up and ramp-down take a lot of time. If you consider what is required for each growth - the machine, the preparation, the time, the people - the overhead saving our approach offers is a significant cost reduction."

The stacks alternate layers of aluminium arsenide with the gallium arsenide. A solution of acid and an oxidizing agent is used to dissolve the layers of aluminium arsenide and free the individual thin sheets of gallium arsenide. The researchers then individually peel off the layers. A soft stamp-like device picks up the layers, one at a time from the top down, for transfer to another substrate, allowing the wafer to be reused for another growth, the university explained.

"By doing this we can generate much more material more rapidly and more cost effectively," Rogers said. "We're creating bulk quantities of material, as opposed to just the thin single-layer manner in which it is typically grown."

The researchers noted that freeing the material from the wafer also opens the possibility of flexible, thin-film electronics made with gallium arsenide or other high-speed semiconductors. "To make devices that can conform but still retain high performance, that's significant," Li said.

As the layers are removed from the stack, they can be laid out side by side on another substrate to produce a much larger surface area, whereas the typical single-layer process limits area to the size of the wafer, the university noted. This is considered an advantage for solar cells.

"For photovoltaics, you want large-area coverage to catch as much sunlight as possible. In an extreme case we might grow enough layers to have 10 times the area of the conventional route," Rogers said. "You really multiply the area coverage, and by a similar multiplier you reduce the cost, while at the same time eliminating the consumption of the wafer."

A shift from silicon-based panels to more efficient gallium arsenide models could make solar power a more cost-effective form of alternative energy. The researchers plan to explore more potential device applications and other semiconductor materials that could adapt to multilayer growth.

A paper on the research was published online Thursday in the journal *Nature*.

Among the paper's co-authors are Matthew Meitl and Etienne Menard, two scientists from Semprius Inc, a North Carolina-based start-up company that is beginning to use this technique to manufacture solar cells.

The Department of Energy and National Science Foundation-funded team also includes University of Illinois postdoctoral researchers Jongseung Yoon, Sungjin Jo and Inhwa Jung; students Ik Su Chun and Hoon-Sik Kin; and electrical and computer engineering professor James Coleman, along with Ungyu Paik, of Hanyang University in Seoul.

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