# NREL Highlights

SCIENCE

# Layering Mismatched Lattices Creates Long-Sought-After Green Light-Emitting Diode

Scientists at the National Renewable Energy Laboratory (NREL) invent a deep green LED that can lead to higher-efficiency white light, lower electric bills.

The white light light-emitting diode (LED) that promises to revolutionize indoor lighting while dramatically lowering electricity costs had been confounded by the so-called "green gap:" the inability to develop light in the green spectrum that can be combined with red and blue to produce white light.

NREL researchers conceptualized a green emission by taking a different look at how the laboratory's solar cell researchers had set a world efficiency record and by changing a key process that had created a red LED.

A good green color of light is between 530 and 570 nanometers (nm) on the Color Rendering Index. Previous attempts to reach this range started from below 520 nm and tried to tune upward. The NREL team decided to start from above 570 nm and tune down.

This idea was based on an approach that the researchers' colleagues used for recent world-record 40.8-percent-efficient inverted metamorphic solar cells. The cells are built by combining layers of barely mismatched lattices of Group 3 and 5 elements, then removing the bottom layer and turning the entire structure upside down.

That world-record multi-layer solar cell used a gallium indium phosphide alloy grown on a substrate of gallium arsenic. The best successes for a red light used that same gallium indium phosphide alloy, while attempts to develop green LEDs typically used a very different alloy—gallium/indium/nitrogen.

The red LED was achieved by growing lattice-matched layers, meaning the space between atoms in the layers of materials is similar. The NREL team used the same substrate, but grew mismatched lattices by inserting strain-graded buffer layers to achieve high-quality metamorphic GaInP emitting optimal 563-nm green light.

Once the concept was understood, a deep green light was produced on the very first try.

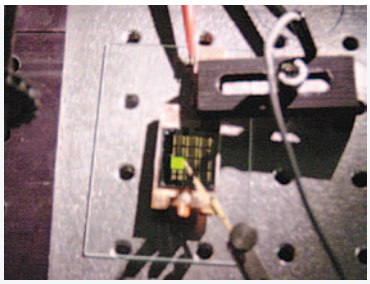

*Photo from NREL/PIX 17121*

## Key Research Results

### Achievement

NREL researchers created the first successful green light-emitting diode (LED) by placing mismatched lattices of gallium indium phosphide on a gallium arsenide substrate.

### Result

By carefully layering Group 3 and 5 elements onto a substrate, NREL researchers bridged the so-called "green gap" and created an inorganic LED with green light of approximately 560-nanometer wavelength.

### Potential Impact

The difficulty of generating green light has slowed the creation of a low-cost LED white light. With this technology, the replacement of incandescent bulbs with inorganic-based LEDs could potentially revolutionize indoor lighting while slashing electric bills in households across the nation—and the world

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**NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.**

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