Physicists Make More Efficient Infrared LEDs

By Kasra Zarei
kasra-zarei@uiowa.edu

The work of one University of Iowa professor focuses on making more efficient and sensitive infrared light-emitting diodes with countless applications to the environment, military, and biomedical research.

Light-emitting diodes are commonplace today, displacing fluorescent light-bulbs as more efficient light sources. There are still much more interesting applications of LEDs, specifically Infrared LEDs (IR-LEDs). The human eye cannot see infrared light, but IR sensors are frequently used in devices for applications such as measuring someone's pulse.

John Prineas, UI professor of physics, conducts research concerning optical properties of semiconductors, materials that are found in nearly every electronic device including LEDs.

As part of a project funded by the National Institutes of Health, one of Prineas's predominant activities has been developing IR-LEDs.

"Different molecules have infrared signatures. Our group focuses on making and detecting light at wavelengths our eyes can't see through our novel LEDs," Prineas said.

Aaron Muhowski, graduate research assistant in physics, says the devices developed through this research have many applications as optical sensors.

"I can tell how ripe my banana is by looking at the yellow and green wavelengths of light, but if I look at certain infrared wavelengths, I can see how much glucose is in blood, how much carbon dioxide is in air, and with a bit more math, I can tell how hot something is," Muhowski said.

Prineas's group fabricates these IR-LEDs using molecular beam epitaxy, a unique method in his lab that can be used to grow rare, semiconductor crystals.

However, one current problem with IR-LEDs occurs after their internal electrical current gets converted to light.

"Most light gets trapped in the device and it can't get pulled out. It just bounces around until it gets re-absorbed and produces heat," Prineas said. "We can only pull around 2-3% of light out of these LEDs, making efficiency a major concern."

A recent paper demonstrated that fireflies have this same problem with getting the bioluminescence out of their lanterns.

“People have found out that fireflies have developed structures on their lanterns to help get the light out,” Prineas said.

This example from nature serves as an inspiration for the work of Prineas and his group. They are trying to build nano- and micro-scale adjustments on LEDs to help solve this efficiency problem.

“If you swim under water about 3 feet and look straight up, you can see out. If you look at the surface 10 feet away, you can't. This is a optical phenomenon called total internal reflection, and it traps a lot of light in our LEDs which makes them pretty inefficient,” Muhowski said.

For their LED devices to be competitive with more traditional infrared sources, this inefficiency needs to be addressed.

LEDs that are more efficient and can provide more light have far-reaching application.

“Brighter and more efficient LEDs could serve as more sensitive optical sensors of biomolecules or serve the military in the form of thermal-scene projectors,” Prineas said.

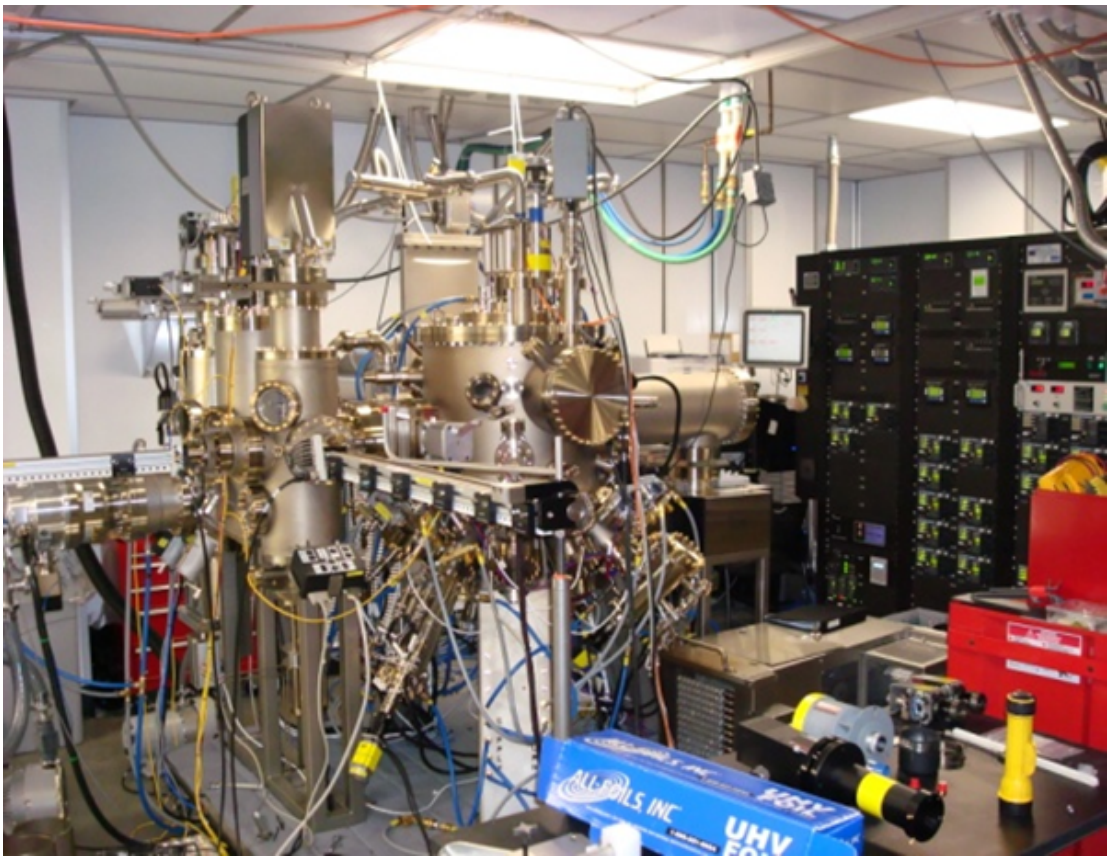
Prineas obtained research funding from the department of defense to further their work to build LED arrays for these projectors which can perform non-destructive simulations of missiles.

Prineas and his students, including Muhowski and Russell Ricker, another UI graduate student in physics, have made great strides in their work, and have started a business to develop and eventually distribute their novel LEDs.

“Our long-term goal is to introduce these into the market as high-power, energy-efficient infrared sources,” Ricker said. “At the present, our LEDs are roughly 100x brighter than other infrared LEDs available on the market.”

Besides the plethora of applications of IR-LEDs, the ability to study the unique properties of novel materials is captivating to individuals like Prineas.

“Our work is driven both by funding the development of these applications and fundamental research such as studying material properties which could have applications to other areas. It’s curiosity driven research which could lead to different things,” Prineas said.



The molecular beam epitaxy apparatus Prineas and his researchers use to fabricate their novel LEDs.