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Lighting the Way

The development of the bright white light-emitting diode (LED) signaled the beginning of the end for the incandescent bulb, which, at only 5 percent efficiency, emits far more in heat than light.

But, even with the LED's phenomenal 50 percent efficiency, can the cooler-burning, longer-lasting LED bulb be made even better? UC Santa Barbara materials professor Chris Van de Walle thinks it might be possible. And that is the kind of research he looks forward to pursuing as the first person named to UCSB's newly established Kroemer Chair in Materials Science.

"I'm extremely honored," said Van de Walle, of the endowment named after Herbert Kroemer, UCSB emeritus professor and 2000 Nobel Laureate. "I'm a great admirer of Herbert Kroemer, and I feel very privileged to be chosen to be the inaugural recipient of the chair that bears his name."

Van de Walle is not only a great admirer of Kroemer's, he also lectures on some of the same material taught by the emeritus professor of electrical and computer engineering: quantum mechanics for engineers.

"He wrote the textbook for it, and I've been using that textbook and trying to live up to his standards by teaching that course as well as possible, and just doing the best possible research and lecturing that I can," Van de Walle said.

As if following in the extra large footsteps of one Nobel Prize winner isn't enough, Van de Walle also has received the John Bardeen Award from The Minerals, Metals

and Materials Society (TMS), “for seminal contributions to the theory and understanding of semiconductor band offsets, doping, defects, and loss mechanisms, and the role of hydrogen in electronic materials.” Bardeen, a physicist and electrical engineer, was one of the inventors of the transistor, and developed a theory of superconductivity. He earned Nobel prizes for each of those achievements.

“I was thrilled to receive this award named after a scientist who had such a tremendous impact,” Van de Walle said of his Bardeen award.

So what does quantum mechanics have to do with creating the next generation of LED bulbs? It’s what Van de Walle, a specialist in computational materials research, uses to examine the mechanisms that prevent the other 50 percent of electrons in LEDs from emitting light.

“In practice, what we do is physics at the atomic level, and we really study how the material behaves at that level. We investigate what happens when the electrons move through the material, and which processes result in emitting light, or what other processes may be happening to the electrons that do not result in light emission, but in heat,” he said. The study of atomic-level physics also lends itself to research into quantum computing, which is poised to become the next revolution in information processing.

The Van de Walle group’s research on materials and semiconductor technology applies to other electronic devices that could benefit from energy efficiency as well. Laptops, for instance, require adaptors to convert power from the grid to the device’s lower voltage requirements. In the process of conversion, however, energy is lost as heat. Not only could that energy be conserved, according to Van de Walle, cooler-running devices last longer and are more reliable. This factor, taken to a large scale, could benefit places like office buildings and data centers, which utilize massive amounts of energy to keep servers cool. On the more personal scale, it could result in savings both in energy usage and on utility bills, and allow people to rely more on off-the-grid forms of energy.

“I’m very excited about energy efficiency,” said Van de Walle. He added that while there is a great push to use solar cells and other forms of renewable energy to decrease reliance on fossil fuels, an equally important aspect is to be able to consume only as much as is needed.

“Solid-state lighting is a great example,” he said, citing the growing use of LED lighting, a technology that became possible when 2014 Nobel Prize winning UCSB professor Shuji Nakamura and his colleagues in Japan mastered the bright blue LED, the final piece of the puzzle that led to the white LED.

Van de Walle received his Ph.D. in electrical engineering from Stanford University in 1986, and then worked as a postdoctoral scientist at the IBM T. J. Watson Research Center in Yorktown Heights, New York. Prior to joining the UCSB faculty in 2004, he was a senior member of research staff at Philips Laboratories in Briarcliff Manor, New York; and a principal scientist in the Electronic Materials Laboratory at the Xerox Palo Alto Research Center.

About UC Santa Barbara

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