LED efficiency puzzle solved by theorists

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Researchers at the University of California, Santa Barbara, say they've figured out the cause of a problem that's made light-emitting diodes (LEDs) impractical for general lighting purposes. Their work will help engineers develop a new generation of high-performance, energy-efficient lighting that could replace incandescent and fluorescent bulbs.

"Identifying the root cause of the problem is an indispensable first step toward devising solutions," says Chris Van de Walle, a professor in the Materials Department at UC Santa Barbara who heads the research group that carried out the work.

Van de Walle and his colleagues are working to improve the performance of nitride-based LEDs, which are efficient, non-toxic and long-lasting light sources. They investigated a phenomenon referred to as "droop"?the drop in efficiency that occurs in these LEDs when they're operating at the high powers required to illuminate a room. The cause of this decline has been the subject of considerable debate, but the UC Santa Barbara researchers say they've figured out the mechanism responsible for the effect by performing quantum-mechanical calculations.

LED droop, they conclude, can be attributed to Auger recombination, a process that occurs in semiconductors, in which three charge-carriers interact without giving off light. The researchers also discovered that indirect Auger effects, which involve a scattering mechanism, are significant?a finding that accounts for the discrepancy between the observed degree of droop and that predicted by other theoretical studies,

which only accounted for direct Auger processes.

In nitride LEDs, "These indirect processes form the dominant contribution to the Auger recombination rate," says Emmanouil Kioupakis, a postdoctoral researcher at UC Santa Barbara and lead author of a paper published online April 19 in Applied Physics Letters. The other authors are Van de Walle, Patrick Rinke, now with the Fritz Haber Institute in Germany, and Kris Delaney, a project scientist at UC Santa Barbara.

LED droop can't be eliminated because Auger effects are intrinsic, but it could be minimized, the researchers say, by using thicker quantum wells in LEDs or growing devices along non-polar or semi-polar growth directions in order to keep carrier density low.

"With Auger recombination now established as the culprit, we can focus on creative approaches to suppress or circumvent this loss mechanism," Van de Walle says.

Provided by University of California - Santa Barbara