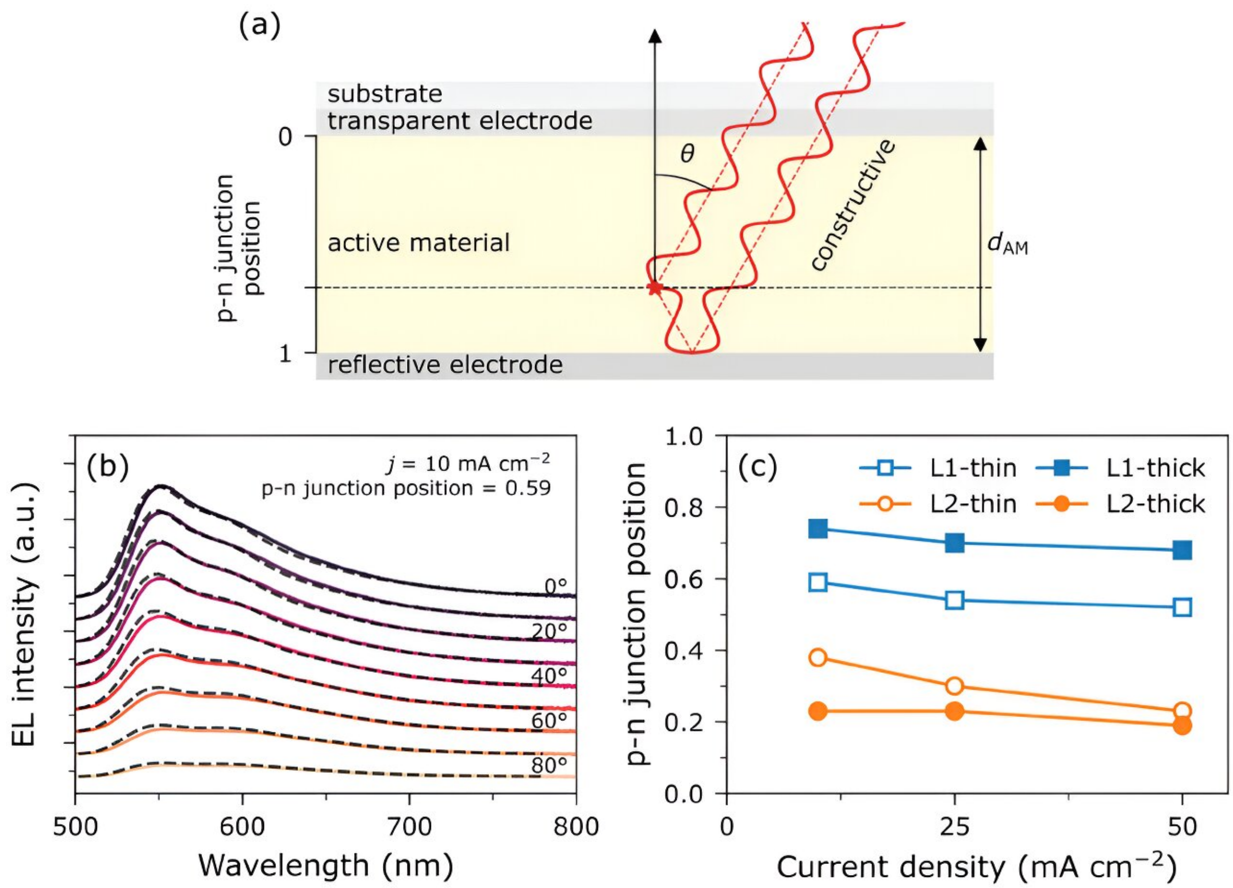
New understanding of energy losses in emerging light source

April 18 2024, by Sara-Lena Brännström



a) Schematic presentation of the optical interference between two light rays that originate from the same spot in the emissive p-n junction (horizontal dotted black line) in a thin-film LEC device, and which are solely distinguished by that one ray is directed directly out of the device through the transparent electrode and substrate, whereas the other ray is directed toward the reflective electrode and first after specular reflection exiting the device. Left part: the p-n junction position is defined to be 0 when located at the transparent electrode interface, and 1 when located at the reflective electrode interface. b) The measured (solid lines) and the best-fit simulated (dashed lines) EL spectra as a function of the viewing angle θ for L1-thin, as recorded at steady state with the device driven by a current density of 10 mA cm^{-2}. The derived best-fit value for the p-n junction position is 0.59. c) The steady-state position of the emissive p-n junction as a function of the current density for the four LEC devices, as identified in the inset. Credit: *Advanced Materials* (2024). DOI: 10.1002/adma.202310156

The light-emitting electrochemical cell (LEC) can be fabricated in a sustainable and cost-effective way on both rigid and flexible surfaces making it suitable for a broad range of applications, like illumination, health care, and signage. Despite its potential, this technology faces a significant challenge: a decrease in emission efficiency at higher electrical currents, a phenomenon known as "efficiency roll-off."

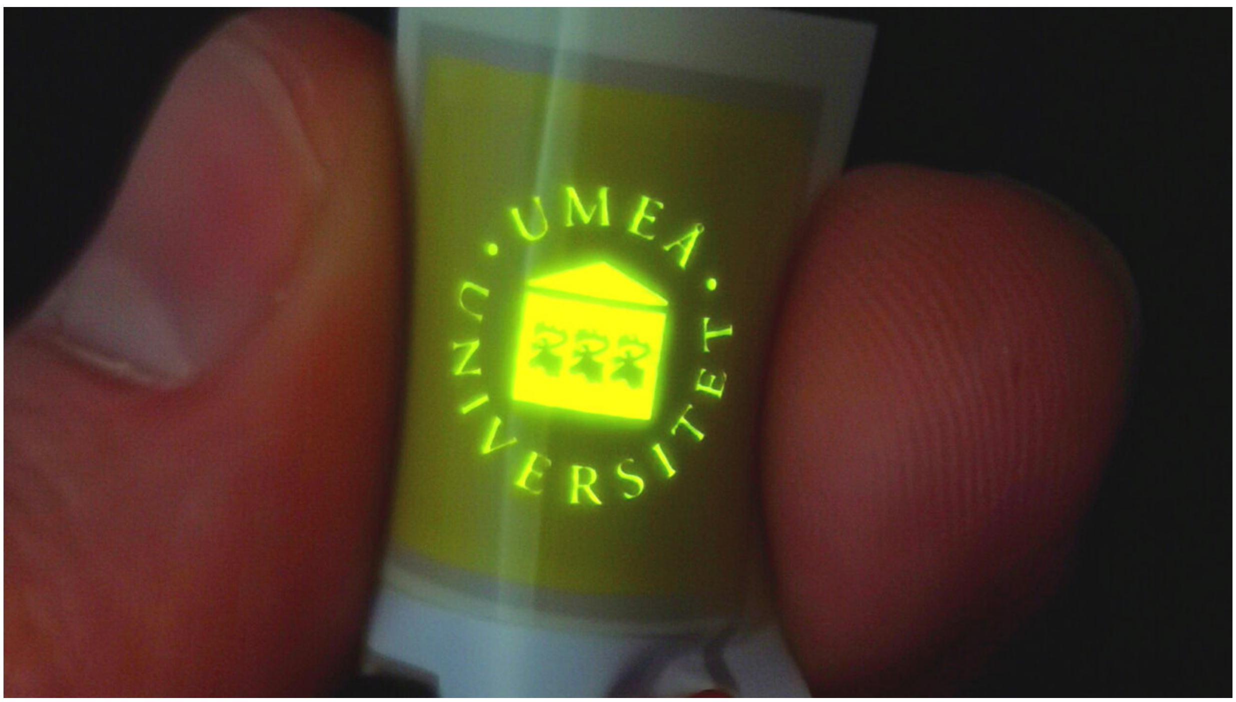
A research team at Umeå University has now developed a method to identify and quantify the primary factors contributing to the LEC efficiency.

"This insight will help us to reduce efficiency loss, allowing us to design and develop LEC devices that deliver bright emission at high efficiency," says Xiaoying Zhang, a doctoral student at the Department of Physics at Umeå University, and one of the authors of the study that was published in the journal *Advanced Materials*.

The breakthrough revolves around a detailed understanding and quantification of the internal so-called quenching processes, where collisions between particles in the device lead to energy loss in the form of decreased light production.

"Think of a box with two kinds of tiny balls bouncing around: one kind can glow, and the other kind can't. If a glowing ball bumps into another ball, it stops glowing, and the light is lost. We found that it is specifically the bumping between glowing and non-glowing balls that is the main reason why our devices lose efficiency," says Xiaoying Zhang.

"This loss mechanism is called 'exciton-polaron quenching' and we found that more than half of the light is lost in this way," Xiaoying continues. The findings of this study therefore imply that developing materials, device designs and operation protocols that reduce the impact of this loss mechanism is a feasible path towards brighter and more efficient LECs.



The bright LEC device with the logo of Umeå University is extremely thin, flexible and lightweigh. Credit: Xiaoying Zhang, Joan Ràfols-Ribé

More information: Xiaoying Zhang et al, Efficiency Roll-Off in Light-Emitting Electrochemical Cells, *Advanced Materials* (2024). [DOI: 10.1002/adma.202310156](https://doi.org/10.1002/adma.202310156)

Provided by Umea University

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