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On the operation of light-emitting electrochemical cells

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Abstract

We are in the midst of a technological revolution that permeates nearly all human activities; artificial light is one of the most visible contributors in this societal change. If more efficient, green, and versatile light sources can be developed, they might improve the life of millions of people around the world while causing minimal damage to our climate and environment. The unique operational mechanism of the light-emitting electrochemical cell (LEC) makes it an ideal fit for some unconventional and emerging uses of light, in for example medicine and security.

By exploiting this operational mechanism, in which mobile ions enable electrochemical doping of a luminescent polymer, we have designed and fabricated new bilayer LEC architectures. The bilayer LEC features patterned light emission that is easily adjustable during fabrication, and that can be configured to suit new applications of light. Given the light-emitting nature of the LEC, it is somewhat surprising that the optical understanding of its operation is rather limited. To fill this knowledge gap, we investigate how the optical properties of the luminescent polymer respond to electrochemical doping. We find that the complex-refractive index spectrum in the active layer of an LEC, as a direct result of the doping, varies in both space and time. The thin-film structure of an LEC implies that computational predictions of its luminous output need to consider internal reflections and interference. Finally, we implement a doping-dependent optical thin-film simulation model. It enables us to precisely replicate the experimental luminance and angle-dependent emission spectrum for a range of LECs with different thicknesses. Using the model we can also identify and quantify many of the different optical loss mechanisms in LECs, which has not previously been done. The insights that we have collected on the path towards our present model will be useful for computational determination of device parameters that are otherwise difficult to acquire.

The improved understanding of the optical operation of LECs is important for the maturation of the technology, as it facilitates formulation of relevant and accurate research questions. Hopefully, our results will accelerate the development of the field, so that useful products based on this technology can become available in the not too distant future.

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