M2 Internship offer

Optimized diffraction and photon recycling for shining LEDs

Research team: i-Lum, light engineering and conversion

Main Location: Ecole Centrale de Lyon

Keywords: Photonic crystals, Light extraction, FDTD simulations

Profile: Optics/Photonics

Duration: 4 to 6 months.

Context
LEDs and LASERs are nowadays widespread in daily life applications. This leads to a huge energy consumption and use of an important amount of critical and costly material. Therefore, increasing their efficiency (emitted optical power vs injected electrical power) and using low-cost materials and technological processes are a major research topics.

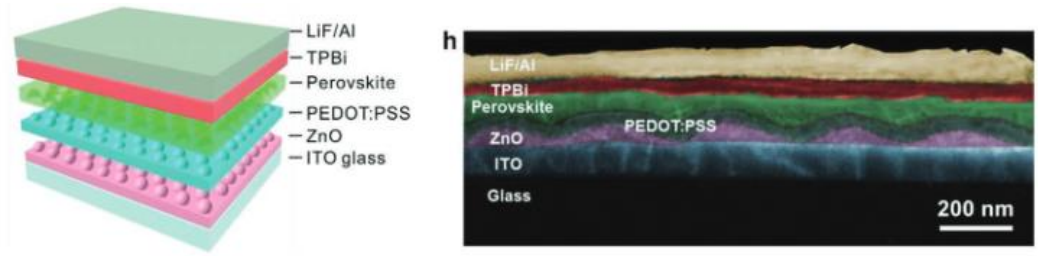

Figure 1. Examples of patterned LED using low cost materials and processes (from [1]): sketch of the stacked materials (left) and SEM cross section of a fabricated sample.

Nanophotonic structures, especially consisting of a periodic, optical wavelength scale patterning of the emitting material, embedded into a stack of layers, can drastically enhance the light extraction from the material, and thus the efficiency [1]. This results from the diffraction phenomenon that also strongly influences the radiation pattern, i.e. the directions where the light is emitted. Another phenomenon [illegible], can also boost the extraction [2], [3]. Both phenomena require an appropriate geometry of the pattern and the stack. Its design requires thus the calculation of the extraction efficiency using a rigorous electromagnetic simulation.
Widely used Finite Difference Time Domain (FDTD) simulation method suits to derive key properties such as light extraction efficiency (LEE) of these devices, but mostly excluding the photon recycling effect.

Research subject
The aim here is to calculate the LEE and the related far field radiation pattern taking into account photon recycling in the active material, in order to provide guidelines for an optimized overall LEE that takes advantage of both diffraction and recycling.

Work plan
After getting trained on a commercial FDTD distribution, the intern will develop a physical model and corresponding simulation methodology of a given device, which involves various simulations and

suitable post-treatment of the intermediate simulation results to derive the final results.
Within this internship, the case of hybrid perovskite LEDs will be considered, since these are low-cost materials that can exhibit a large recycling effect.

Profile
The student will have a background in photonics and will show some interest for simulation work.

Possible perspective
This internship may be followed by a PhD on microLEDs starting in September / October 2024.

References

[1] Y. Shen *et al.*, « High-Efficiency Perovskite Light-Emitting Diodes with Synergetic Outcoupling Enhancement », *Advanced Materials*, vol. 31, n° 24, p. 1901517, 2019, doi: 10.1002/adma.201901517.
[2] C. Cho *et al.*, « The role of photon recycling in perovskite light-emitting diodes », *Nat Commun*, vol. 11, n° 1, p. 611, janv. 2020, doi: 10.1038/s41467-020-14401-1.
[3] C. Cho, Y. Sun, J. You, L.-S. Cui, et N. C. Greenham, « Enhanced Photon Recycling Enables Efficient Perovskite Light-Emitting Diodes », *Advanced Functional Materials*, vol. n/a, n° n/a, p. 2411556, doi: 10.1002/adfm.202411556.

Contacts

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