Metallic arrays for directional light-emitting devices

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The development of efficient light sources based on light-emitting diodes (LEDs) is a central goal for solid-state lighting (SSL). The most widely employed route to achieve white light using LEDs consist in combining an electrically driven blue LED and a material, usually known as a *phosphor* that absorbs part of the blue light and emits in the green-to-red region of the electromagnetic spectrum. The critical role played by this emitting material in SSL has guided most of material research efforts in this field. With the advent of stable and ultra-high efficient emitters, research in SSL is shifting towards the use of nanostructures that allows an accurate control over the intensity, color content, directionality and polarization of the emission. Nanostructuring strategies represent a versatile approach to tailor the emission characteristics of the phosphor without changing its intrinsic structural properties or chemical composition.

Metal nanoparticles provide unique ways of controlling light at length scales smaller than the wavelength through the excitation of surface plasmons. Herein, we demonstrate that the emission of a phosphor-converted LED can be boosted by aluminum nanoparticles that enhance the directionality of the emitted light such that it is preferably emitted straight from the surface, rather than toward the side. The emission in this direction is enhanced by more than a factor of 60 for a specific color. This directional enhancement is the result of the plasmonic enhanced excitation of the phosphor and its decay into collective resonances supported by the array of nanoparticles. These lattice-induced resonances arise from the coupling of localized surface plasmon polaritons to photonic modes induced by the array. In contrast to localized surface plasmon resonances, collective resonances have a large spatial extension and can couple very efficiently to free space radiation due to their hybrid photonic-plasmonic character. These features lead to a highly directional emission in defined directions which can be controlled by the shape and dimensions of the particles and by the lattice geometry. This demonstration opens a new path for fundamental and applied research in SSL in which plasmonic nanostructures are able to mold the emission with unprecedented precision.[1]

References

[1] G. Lozano, D. J. Louwers, S. R. K. Rodríguez et al., *Light: Sci. Appl.* 2, e66 (2013).