which electrons and holes are injected into the active region from cladding layers and metal electrodes, electron-beam excitation uses highly accelerated electrons to generate electron–hole pairs inside the target material. Electron-beam excitation requires additional components such as a high-voltage electron gun and electromagnetic lenses, which inevitably results in bulkier UV emitters. Although electron–hole generation using electron-beam excitation may not be the most convenient design for solid-state devices, the performance of the emitter reported by Oto *et al.* is astounding.

The power efficiency of electron-beam-excited devices generally depends on the acceleration voltage of the electrons, and the authors found that the efficiency of their device was indeed strongly dependent on the acceleration voltage. The maximum power efficiency of 40% was measured when using an acceleration voltage of 8 kV. This result is remarkable given the much lower efficiencies attained by conventional p–n junction devices emitting at the same wavelength. Conventional deep-UV p–n junction diodes have typical external quantum efficiencies of only a few percent[6], and this decreases rapidly for shorter wavelengths (Fig. 1). The external quantum efficiency demonstrated by Oto *et al.* is around 100 times higher than those of UV LEDs emitting at similar wavelengths.

Electron-beam excitation has historically been an ineffective way of making highly efficient UV emitters, owing to self-absorption and the typically low radiative recombination rates of the materials used. The authors attribute the high efficiency of their UV emitter to the strong carrier confinement provided by high-quality AlGaN/AlN quantum wells (the estimated internal quantum efficiency is about 57%) as well as to the proper design of the sample structure for electron-beam excitation, including the depth of the quantum wells under the sample surface. This unique design, which is optimized for electron-beam excitation, provides an excitation yield (the ratio of the sum of the electron–hole pair energies generated by one incoming electron to the energy of the incoming electron) of at least 60%. This result strongly suggests that improving the hole injection efficiency is the next critical factor in the development of highly efficient III–V nitride-based deep-UV emitters. The authors conclude that their results could be a milestone for realizing next-generation UV light sources of great ecological and economical benefits, which is indeed a very agreeable conclusion. ❐

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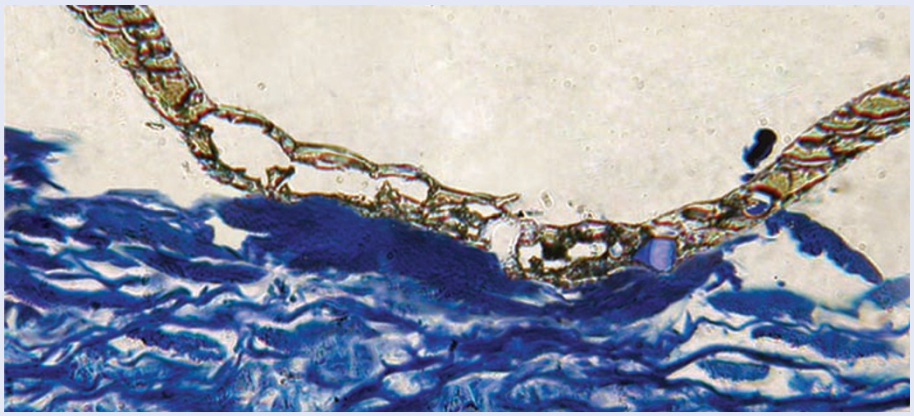
BIOPHOTONICS

Make it stick

Chitosan — a processed form of chitin, the long-chain polymer commonly found in the exoskeleton of crustaceans — is attracting attention for aiding post-operative wound closure, thanks to its antimicrobial activity and ability to stimulate tissue regeneration. However, fixing chitosan to the target area is not always easy.

Now, Paolo Matteini and colleagues from Italy have shown that laser activation can successfully bond a composite of chitosan and gold nanorods to biological tissue (*Adv. Mater.* doi:10.1002/adma.201002228; 2010). Light from a near-infrared laser drives an electromagnetic resonance in the gold nanorods, providing the heat required for the bioadhesive process. The result is an efficient laser-activatable bioadhesive for tissue repair and drug delivery.

The researchers first doped the chitosan films with gold nanorods (~60 nm long and 15 nm wide) in an aqueous acidic solution. Evaporation and washing out resulted in pliable films 0.8 cm in diameter and ~40 μm thick. The gold nanorods exhibited light absorption at wavelengths of 520 nm and 800 nm, so the team chose to use fibre-coupled 810 nm AlGaAs diode lasers because a longer wavelength allows for deeper penetration.



"We used pulses in the millisecond regime to initiate the cascade of physiochemical events leading to the activation of chitosan groups and eventual adhesion with a confining matrix," Matteini explained.

Preventing the gold nanorods from aggregating is critical for their use in medical applications. Aggregation can cause complicated plasmonic coupling, and may result in poor photothermal conversion efficiency. The team found that the dispersion of gold nanorods within the chitosan network proved to be homogeneous throughout the film when using intermediate chitosan concentrations of 3–4% and gold nanorods densities of less than 200 pM.

The team is now interested in the possibility of precisely securing hybrid nanorod–chitosan films to a variety of biological matter upon laser activation. This may lead to a range of future opportunities for such materials, including advanced tissue repair and localized drug delivery.

DAVID PILE