Bright sparks make gains towards plastic lasers of the future

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The researchers hope lasers in CD players may one day use plastic laser diodes

Imperial researchers have come one step closer to finding the 'holy grail' in the field of plastic semiconductors by demonstrating a class of material that could make electrically-driven plastic laser diodes a reality.

Conventional electrically-powered laser diodes used in everyday consumer goods like DVD players are currently based on inorganic semiconductor materials such as gallium arsenide, gallium nitride and related alloys. The term 'semiconductor' describes the material's ability to pass an electric current, which lies somewhere between that of a metallic conductor and that of an insulator.

In the case of a laser diode, the current comprises positive and negative charges that combine inside the material and produce the initial light required to begin the lasing process. If the initial light can be forced to pass back and forth through the semiconducting material many times, in a way that amplifies its strength on each pass, then after a short time a spectrally narrow, intense and directional laser beam emerges.

The last two decades have seen tremendous developments in new organic-molecule-based semiconductors, including a special class of plastics. Many important devices based on such plastics have successfully been developed, including light emitting diodes for displays and lighting, field effect transistors for electrical circuits, and photodiodes for solar energy conversion and light detection. However, despite over a decade of worldwide research, plastic laser diodes remain the only major device type not yet demonstrated.

One of the main stumbling blocks is that, until now, it was widely considered that plastic semiconductor laser diodes would be impossible to produce because scientists had not found or developed any plastics that could sustain a large enough current whilst also supporting the efficient light emission needed to produce a laser beam.

Now a team of Imperial physicists, publishing their findings in *Nature Materials* in April, have done just that. The plastics studied, synthesised by the Sumitomo Chemical Company in Japan, are closely related to PFO, an archetype blue-light emitting material. By making subtle changes in the plastic's chemical structure the researchers produced a material that transports charges 200 times better than before, without compromising its ability to efficiently emit light - indeed the generation of laser light was actually improved.

Professor Donal Bradley, lead author of the new study and head of Imperial's Department of Physics said: "This study is a real breakthrough. In the past designing polymers for electronic and optoelectronic devices often involved maximising one key property in a material at a time. When people tried to develop plastic semiconductors for laser diode use, they found that optimising the material's charge transporting properties had a detrimental effect on its ability to efficiently emit light, and vice versa."

"The modifications made to the PFO structure have allowed us to convincingly overcome this perceived incompatibility and they suggest that plastic laser diodes might now be a realistic possibility", added co-author Dr Paul Stavrinou.

Low cost manufacturing and easy integration possibilities are not the only potential advantages of developing lasers based on plastics. Currently available laser diodes do not readily cover the full visible spectrum, which limits display and many spectroscopic applications, and precludes access to the full range of wavelengths supported by the standard plastics used for waveguides and optical fibres.

Professor Bradley, Dr Stavrinou and their colleagues point out that plastic laser diodes could operate across a much more substantial wavelength range spanning the near ultraviolet to the near infrared.

The Imperial College physics team, in conjunction with polymer synthesis teams at the Sumitomo Chemical Company and in collaborating university groups, now plans to explore the generality of their approach to manipulating chemical structure to target specific device requirements. They will also study electrically driven structures, paying particular attention to understanding and managing the additional optical losses that can arise from the presence of conductive electrode layers in close proximity to the light emission material.

Professor Bradley’s *Nature Material’s* paper can be read in full here:

www.nature.com/nmat/journal/v7 … 5/full/nmat2165.html

Source: Imperial College London