Photonics: strong vibrations

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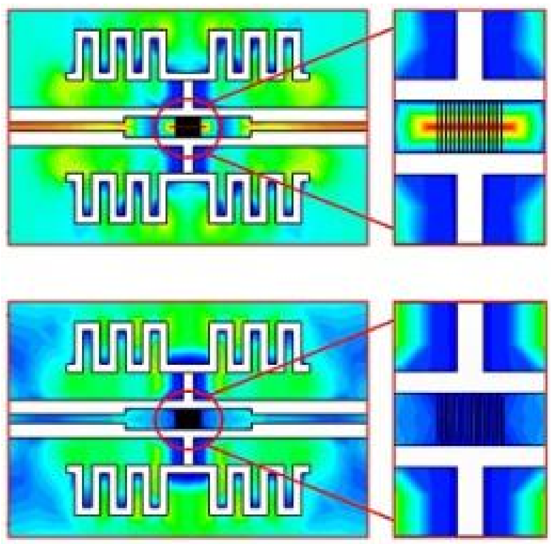

Terahertz (THz) generation. A strong THz emission from the center of the device is observed in the tip-to-tip design (top). The electrodes are the black lines in the center of the device. The colours show the electric field from low (blue) to high (red) values. Much weaker electric fields and THz emission are seen in the interdigitated electrode design (bottom). Credit: From Ref. 1 © 2012 H. Tanoto

A new approach to generating terahertz radiation will lead to new imaging and sensing applications. The low energy of the radiation means that it can pass through materials that are otherwise opaque, opening up uses in imaging and sensing — for example, in new security scanners. In practice, however, applications have been difficult to implement.

Terahertz (THz) electromagnetic radiation has promising properties for a wide range of applications. The low energy of the radiation means that it can pass through materials that are otherwise opaque, opening up uses in imaging and sensing — for example, in new security scanners. In practice, however, applications have been difficult to implement. Terahertz radiation is a difficult portion of the electromagnetic spectrum to utilize. The frequencies of the region are higher than the mega and gigahertz frequencies achievable with conventional electronic circuits, but are too low-frequency to be compatible with optical instruments.

“The key challenges for THz technology are the development of a compact high power source and high sensitivity detector operating at room temperature,” explains Jinghua Teng of the A*STAR Institute of Materials Research and Engineering. A recent discovery made by Teng’s team of a new, efficient protocol for THz wave generation that utilizes the enhancement of light between nanometer-scale electrical contacts may provide a solution.

One method for creating continuous THz radiation involves directing two optical laser beams of almost similar frequencies at a suitable nonlinear material, such as certain semiconductors causing light emission exactly at the frequency difference of the two laser beams. If this difference is sufficiently small, the radiation produced falls within the THz spectrum.

However, this process is rather inefficient and requires strong light fields. Fortunately, strong amplification of light can occur near small metallic objects that act as mini antennas. This antenna effect occurs with the small metal contacts that are needed to link the non-linear material that creates the THz emission — in the current case a variant of the common semiconductor gallium arsenide.

Normally, these electrical contacts are arranged such that they resemble the fingers of interlocked hands reaching into each other. However, the

A*STAR researchers developed a revised design in which the electrodes are arranged tip to tip (see top of the above image). This means that the gap between the electrodes is much narrower and also results in the alignment of the electrical field with the THz light waves, which leads to a considerably stronger antenna enhancement.

Using the new arrangement the A*STAR team were able to generate THz radiation of about 100 times the strength of that produced by conventional systems. The work suggests that these devices can be miniaturized significantly for compact yet powerful THz sources. "This approach will greatly facilitate the applications of THz technology in areas such as gas sensing, non-destructive inspection and testing, high resolution spectroscopy, product quality monitoring and bio-imaging," says Teng.

More information: Tanoto, H. et al. Greatly enhanced continuous-wave terahertz emission by nano-electrodes in a photoconductive photomixer. Nature Photonics 6, 121–126 (2012).

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