Tuning into terahertz

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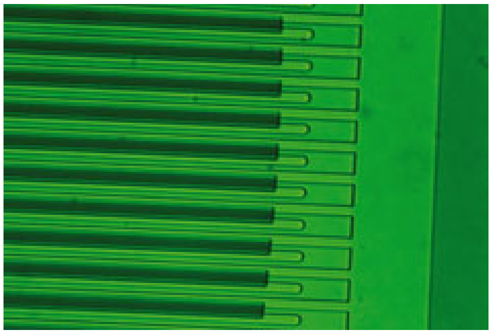


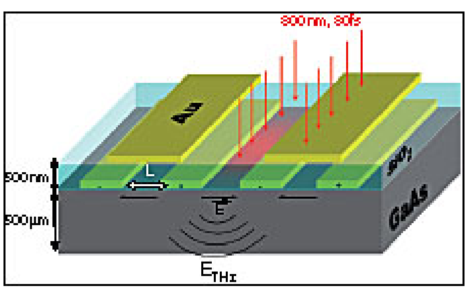
Interdigitated photoconductive antennas have been engineered to reach even more of the THz spectrum for pulsed spectroscopy and imaging.

One of the main sources of THz radiation, the interdigitated photoconductive antenna, can now be ‘tuned’ to THz frequencies that were previously difficult to reach. Researchers at the Ecole Normale Supérieure in France found that changing the spacing between the electrodes in the antenna’s structure enables the emission spectrum to be centred at a chosen frequency; a property that will be useful for spectroscopy and imaging, where access to particular parts of the THz spectrum is needed.

The generation gap

There are many possible applications in the THz range (0.1-10 THz) including explosives and drugs detection, medical imaging, gas detection, high-speed communications and fundamental studies of the physics of materials or very low energy systems (1 THz~4 meV). However, despite intense research efforts, there have been many challenges that have not yet been overcome in achieving a miniature, efficient THz source. Today’s research is mainly focused on a variety of different compact optoelectronic devices like photoconductive antennas (PCAs) which operate at room temperature but need an external laser excitation, or THz quantum cascade lasers which are powerful but currently operate at cryogenic temperatures. PCAs have been used and studied as a source of THz radiation for over 20 years. One of the most efficient is the interdigitated PCA with its electrode comb geometry which radiates in the THz range when illuminated with, typically, an infrared femtosecond pulsed laser. They are now increasingly being used in laboratory applications as they radiate with broadband emission and high power; they suffer little from diffraction effects as the illuminated surface area is large; and they operate at low electrical input power.

A selective response



The team at Ecole Normale Supérieure have been developing and using interdigitated PCAs as a pulsed source for studies with a THz time-domain (TDS) setup which is used to probe physical or chemical properties related to low energy interactions within materials or compounds. They have been studying the geometry of interdigitated PCAs in order to understand their mechanisms better and therefore create more efficient THz sources. In their most recent investigation, they found that the emitted spectral peak frequency increased from 0.73 to 1.33 THz as the spacing between the electrodes in the structures was decreased from 20 to 2 µm. This result enables the frequency response of an interdigitated PCA to be selected by the design of its electrode spacing geometry. A big challenge that the team faced to achieve this result was the fabrication of the devices with the electrode spacing on the micron level as the standard UV contact lithography technique starts to reach its limits. They overcame this by optimising the processing procedure and the team next plan to develop interdigitated PCAs to cover the high frequency part of the THz range using the same laser source. “This could be achieved by further reducing the electrode spacing of the interdigitated structure but it will need a different lithography technique,” said Julien Madéo, a researcher at Ecole Normale Supérieure. “We are also investigating new interdigitated geometries with different patterns to achieve higher frequency emission.”

Future improvements

With worldwide research efforts underway to achieve more efficient THz sources, the team predict that the use of PCAs as THz sources will rapidly progress as a better understanding is developed from experiments and simulations. “We believe that electromagnetic simulations of these devices will continue to be important and allow the antenna geometry to be adapted to the required spectral range,” said Madéo. “Another challenge though is that these structures exhibit a weak efficiency (< 1%), and high power and expensive pulsed lasers are needed to produce relatively strong THz electric fields. We will need to think about new geometries and new materials to improve these issues, possibly combined with the use of cheaper and compact fibre-based laser systems. Improving these types of sources will permit the THz technological range to become mature and comparable to those used in microwave electronics and infrared optical systems.”

The Letter presenting the results on which this article is based can be found on the IET Digital Library.
For further reading, please visit www.lpa.ens.fr

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