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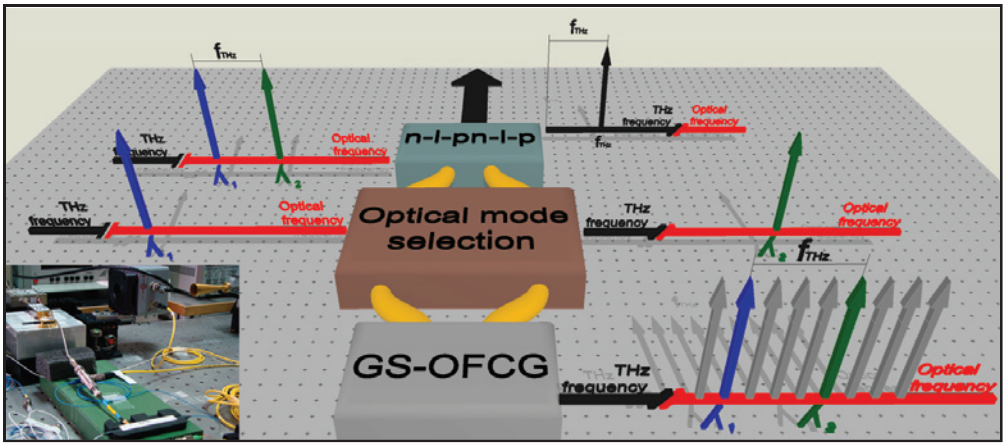
'Ultra narrow linewidth CW sub-THz generation using GS based OFCG and n-i-pn-i-p superlattice photomixers', Á. R. Criado, C. de Dios, G. H. Döhler, S. Preu, S. Malzer, S. Bauerschmidt, H. Lu, A. C. Gossard and P. Acedo

An international team of researchers has developed a photonic sub-THz source with excellent signal quality, tunability and stability. Members of the Spanish arm of the team talk to us about the potential and challenges of photonic sub-THz generation



ABOVE: A schematic view of how the frequencies are generated and processed through the setup. Inset: The experimental setup with the complete gain switching (GS)-OFCG (bottom-left) and the n-i-pn-i-p photomixer (top-right)
Bottom: Members of the team from Spain (left) and Germany (right). From left to right: Pablo Acedo, Á. Rubén Criado, Cristina de Dios, Gottfried Döhler, Stefan Malzer, Sascha Preu. Not pictured here, the team also includes S. Bauerschmidt (Germany) and the US members, from UCSB: H. Lu and A. C. Gossard

Why the interest in sub-terahertz generation?

The reason is basically the high number of applications identified in the sub-THz and THz domains, some from several decades ago, like spectroscopy applications, especially in the radioastronomy field. Others have become more extensively used in recent years, like imaging forsecurity and biomedical applications and short-distance high-data rate communications. Moreover, new applications are appearing every year, including in art and structure conservation and even holography. Maybe the most exciting application that may appear in the near future is high sensitivity, low phase noise THz heterodyne systems, for example for radioastronomy receivers.

What are the limitations of current approaches?

There are two bottlenecks common to all compact sub-THz generation systems: power and maximum frequency of operation. There are also limitations that only exist for some approaches. Up to now, upconversion using Schottky multipliers has been the solid state solution with best performance in terms of power, so it used to be the preferred commercially available sub-THz generation system.

However, photonic generation is able to provide unique features that cannot be offered by other alternatives, in tunability range and especially remote distribution and generation. You can distribute your optical source signal through optical fibre with very low losses (0.2 dB/km), EMI immunity and low cost to one or several remote photomixers where the THz generation is performed. However the output power is still lower than that achievable by electronic approaches based on multiplication. But, now that photonic systems are able to match or even surpass electronic systems in terms of signal quality, the photonic approach is a great candidate to fulfil THz users' requirements.

What have you achieved in the work reported in your Letter?

We have developed a photonic sub-THz source with all the advantages of photonic THz generation, which matches or even surpasses the signal quality, tunability and stability of the best commercially available electronic solutions. The system has good potential for commercial solutions because it provides all the characteristics required by the market; very high signal performance (unique for a photonic solution) and a simple and compact scheme with a continuous and ultra-high resolution tunability covering the whole frequency range. It is also low cost, has low energy consumption, is highly stable and reliable with good linewidth and phase noise characteristics.

What were the breakthrough elements in the work?

Our generation scheme consists of three main parts: the optical source, the optical mode selection scheme, and the sub-THz photomixer. For the last three years we have been working with several alternatives for each part. We finally arrived at a compact, cost-effective and high performance multimode source, providing continuous tunability and great mode coherence. Together with the n-i-pn-i-p superlattice photomixers provided by our colleagues in Germany, these were the two key factors in reaching the final scheme.

This work was a collaboration across three countries and four institutions. What did each part of the team bring to the project?

We began our collaboration about a year ago, when G.H. Döhler came to Universidad Carlos III de Madrid (UC3M) as a visitor under the Excellence Chair Programme. He and his colleagues in Germany (both at Max Planck Institute for the Science of Light and University of Erlangen) designed and developed the photomixer devices. As these structures contain ErAs as an essential ingredient, they are grown in the group of A.C. Gossard from University of California, Santa Barbara (UCSB), who pioneered growth and applications of layers containing ErAs. UC3M implement the optical source and mode selection scheme and set up the complete system. Collaboration between the groups allows us to cover the whole chain, from photomixer manufacturing and optical source development to system level implementation.

What applications of this work are you expecting to see and what are the longer term goals your team is moving toward?

Applications like high resolution spectroscopy or THz local oscillators that depend on a high quality signal. We are now working with a spin-off of UC3M - Luz WaveLabs – for the development of a commercial THz source based on our scheme. Providing higher THz frequencies and power and a wider frequency range will be top of our list of priorities.

A key issue is downsizing and integration of the components to come up with a small and cost efficient prototype system. Beyond that, the longer term goal is improving the system to arrive at a commercial solution and cost-effective approaches for optical frequency comb generators with optical tunability well above 1 THz. In addition, in THz detection, our aim is heterodyne systems that make use of our low-phase noise photonic local oscillator.