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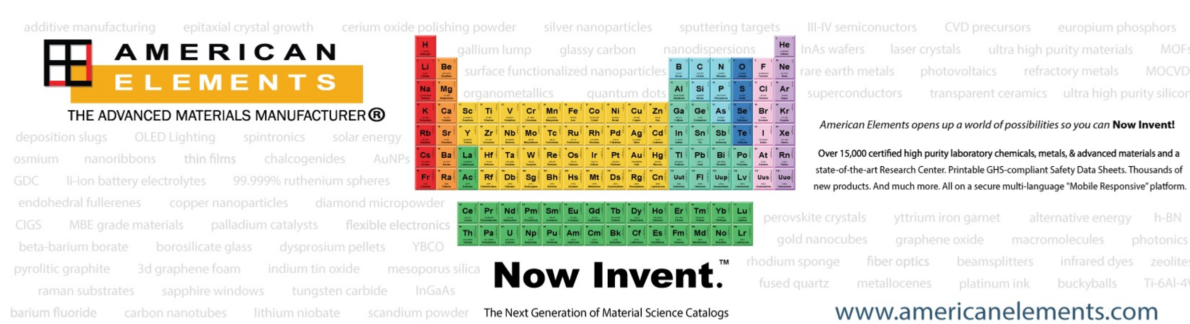

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Preface to Special Topic: Frontiers on THz photonic devices

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Terahertz (THz) radiation bridges the gap between microwave and optical wavelengths and spans the frequency range from 0.1 to 10 THz. Imaging and sensing with THz electromagnetic radiation have already found applications in science and industry, such as security and safety screening, process monitoring, non-contact material characterization, and medical, biological, and pharmaceutical research. The THz frequency range further provides an enormous unlicensed bandwidth which is being explored for high-speed short-range wireless communication. This least explored part of the electromagnetic spectrum has developed rapidly over the last 30 years. It has grown from an emerging field of research into an interdisciplinary field with many industrial applications. The established neighbouring frequency regimes, microwave and optics, have played a significant role in this transformation. Meanwhile, these adjacent bands themselves have gone through significant changes due to the emergence of new material systems including micro- and nano-materials leading into novel device designs. Consequently, enabling further advances in devices performance and size reduction for THz components. The key goal of this special topic issue is to highlight recent THz photonic devices that have benefited from advances in microwave and optics especially the structured material paradigm, e.g., plasmonics, metamaterials, and metasurfaces. Metamaterials are human-made artificial composite materials with subwavelength resonant elements exhibiting exotic properties not achievable by natural materials. Metasurfaces are basically two-dimensional metamaterials with the advantage of taking less physical space, lower losses, and ease of fabrication. This issue contains 1 tutorial, 4 invited, and 8 contributed articles as explained below.

Headland *et al.*[1] provide a comprehensive tutorial on THz beamforming which not only gives insight on the principles of THz wavefront engineering from concepts to realization but also elegantly reconciles the microwave and optical techniques. Terahertz wavefront engineering is an indispensable part of many THz applications including sensing, imaging, security screening, and wireless communication.

Chang *et al.*[2] experimentally demonstrate that cascading three layers of hybrid (dielectric and metal) metasurfaces can lead to a high-performance narrowband bandpass filter (high transmission with fast roll-off). Liu *et al.*[3] report on the first demonstration of an active THz quarter-wave converter with ultra-broad bandwidth performance, which is achieved using vanadium dioxide (material with an electrically driven metal-insulator phase transition). Mitrofanov *et al.*[4] report on an efficient photoconductive terahertz detector. This was achieved by embedding an all-dielectric metasurface in the THz detector resulting in enhanced optical absorption. The photoconductive antennas are also one of the most conventional devices used for THz generation, albeit low optical-to-THz conversion. Gupta *et al.*[5] demonstrate how a thin nano-layer of dielectric can enhance THz emission efficiency of these conventional photoconductive antenna. Lisauskas *et al.*[6] propose to exploit rectification of field-effect transistors for monitoring of temporal characteristics of pulsed THz sources. Kornienko *et al.*[7] investigate a calibration scheme for THz nonlinear-optical detectors based on spontaneous parametric down-conversion.

This issue contains articles where strong THz field and matter interaction is achieved using structured material systems. Atakaramians *et al.*[8] report on an enhanced THz magnetic dipole source achieved by placing a subwavelength fiber next to a subwavelength aperture, where the enhancement is due to the excitation of the Mie resonances. Vogt and Leonhardt[9] report on ultra-high quality factor THz whispering-gallery-modes (WGMs) using continuous wave (CW) THz spectroscopy. Ma *et al.*[10] propose a microfluidic channel integrated in a domino waveguide that supports spoof SPPs as a liquid sensing platform at THz frequencies. Serita *et al.*[11] demonstrate experimentally a THz microfluidic chip capable of measuring a 31.8 fmol of ion concentration in a 318 pl water solution. This elegant THz microfluidic chip is attained via integration of metasurfaces in a laser THz emission microscope (LTEM).

This issue also comprises articles on THz wireless communication at sub-terabits-per-second speeds, one of the most exciting future applications of THz technology. Ma *et al.*[12] report on the experimental characterization of THz carrier waves to gain an understanding of their performance in indoor and outdoor environments. Withayachumnankul *et al.*[13] demonstrate a wide bandwidth, high gain, and low dissipation supporting antenna to compensate the free space path loss. This is realised using dielectric rod arrays, where a pair of such antennas can handle bit-error-free transmission at speeds up to 10 Gbps. Stefani *et al.*[14] report on the realization of modes with orbital angular momentum (OAM) within a flexible polymer waveguide that can be twisted in a tunable and reversible manner, opening new avenues to further increase the THz data transmission rate.

In conclusion, this issue was created with the intent to highlight recent cutting-edge THz photonic devices. Our special thanks to Ben Eggleton, Editor-in-Chief, who strongly supported the idea of this special topic, and Benedetta Camarota and Erinn Brigham for the technical assistance with publishing.

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