From visible to THz optics

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Abstract—This is a brief editorial overview of the work devoted to THz radiation in the current issue.

The scientists working on electromagnetic radiation often discuss where the border between optics and microwave technology is located. It seems to be somewhere in the THz range (0.1–10THz). The corresponding wavelengths vary from 30µm to 3mm. One can often consider a THz system as a set of emitters, receiver antennas, dipoles etc. On the other hand, the same THz setup is sometimes considered as composed of optical elements like mirrors, lenses, prisms etc.

While using optical methods for the THz range scientists should be aware of many similarities, but also existing differences. For example, methods of designing optical elements based on geometrical optics seem to be inefficient for THz. It is due to the fact that the dimensions of elements are of the order of tens or hundreds of wavelengths. For visible light optics the same parameter is of the order of tens of thousands of wavelengths or more. Nevertheless, the utilization of wave optics in the case of elements for THz is very promising.

Both active and passive THz systems require optical components which are mainly used for concentrating radiation on a single detector. However, the most advanced THz devices can create 2D images. Sometimes an additional spectral analysis is possible. The mentioned systems are typically based on the line of detectors and mechanical scanning. Recently, it is also possible to find THz cameras based on a real 2D matrix of detectors. The mentioned devices require optical imaging systems which can provide high performance for a relatively broad spectrum. Active devices need additionally optical components providing the expected shape of an illumination beam.

The current issue of the Photonics Letters of Poland is generally devoted to THz radiation. The papers of this issue describe selected recent developments in the key areas of THz radiation – from detection and generation, modeling, material characterization and detection to applications of the existing THz devices.

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The first three papers are devoted to THz Time Domain Spectroscopy (TDS). TDS setups are broadly utilized for material characterization. The basic setups enable to measure complex refractive indices of the sample as a function of frequency. The optimal selection of the measurement method is described in the letter of F. Garet *et al*.. More complex goniometric TDS setups need special calibration (J. Bomba *et al*.) but enable additional, angular analysis of the scattered signal (Ch. Ketchazo *et al*.).

The following papers are focused on the utilization of commercially available passive THz scanners: P. Jung with colleagues evaluate possible application of THz imaging through the smoke and M. Kowalski with colleagues concentrate on image processing for the detection of objects hidden under clothes.

The next two papers are devoted to THz sensor technology and detection methods (R. Venckevičius *et al*. and D. Yavorskiy *et al*.). Those works may lead to the construction of a 2D matrix of the THz sensor for up to 1.5THz range. On the other hand, a single detector with an active THz system with a tunable laser can be used for the remote detection of harmful materials (N. Palka *et al*.). Experimental methods are typically supported by modeling methods (W. Golebiewski). Moreover, future THz systems require active optical components based on new types of liquid crystals (U. Chodorow *et al*.).

The impact of modern THz systems on society and civilization can be far-reaching. From a medical point of view, high-performance optical elements for THz are perfect for conducting innovative experiments involving rapid and reliable detection of tumor tissues. On the other side, THz systems could open up the way to the next generation of passive security scanners for the remote detection of explosives in public space, counter-terrorist protection or in battlefield conditions. Another impact could be the introduction of highly efficient elements for high-bitrate telecommunication (in the 500-900GHz band), leading to an increased throughput of modern world-wide networks, which is compulsory for future TV channel broadcasting.

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