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High-power Terahertz Waves Generators and Their Application in the Modern World

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Nowadays with the development of electromagnetic technology humanity got the opportunity to use previously inaccessible types of electromagnetic radiation that can replace the types of electromagnetic waves currently used in science and industry.

Terahertz radiation is the type of radiation that falls in between infrared radiation and microwave radiation in the electromagnetic spectrum, and it shares some properties with each of these. Terahertz radiation travels in a line of sight and is non-ionizing. Like microwaves, terahertz radiation can penetrate a wide variety of non-conducting materials: clothing, paper, cardboard, wood, masonry, plastic and ceramics. The penetration depth is typically less than that of microwave radiation. Like infrared, terahertz radiation has limited penetration through fog and clouds and cannot penetrate liquid water or metal. Terahertz radiation can penetrate some distance through body tissue like x-rays, but unlike them is non-ionizing, so it is of interest as a replacement for medical X-rays.

Today the most promising fields of use for terahertz waves are medical imaging (due to its harmless nature for human body, unlike X-rays), security (because terahertz radiation can penetrate most of commonly used materials and many materials have unique spectral “fingerprint” in the terahertz range), scientific use in biology and chemistry and other specific fields of human life. It should be noted that THz waves are a type of non-ionizing radiation, meaning they pose no risk to human health, that is why this technology is also used in some airports to scan passengers and detect dangerous objects and substances. Terahertz radiation is emitted as part of the black-body radiation from anything with a temperature greater than about 2 kelvins. While this thermal emission is very weak, observations at these frequencies are important for characterizing cold 10–20 K cosmic dust in interstellar clouds in the Milky Way galaxy, and in distant starburst galaxies [1].

However, THz waves are not widely used because they are costly and cumbersome to generate. But new technology developed by researchers at EPFL could change all that. The team at the Power and Wide-band-gap Electronics Research Laboratory (POWERlab) built a nanodevice that can generate extremely high-power signals in just a few picoseconds, or one trillionth of a second, which produces high-power THz waves. The compact, inexpensive, fully electric nanodevice generates high-intensity waves from a tiny source in next to no time. It works by producing a powerful "spark," with the voltage spiking from 10 V (or lower) to 100 V in the range of a picosecond. The device is capable of generating this spark almost continuously, meaning it can emit up to 50 million signals every second. When hooked up to antennas, the system can produce and radiate high-power THz waves. The device consists of two metal plates situated very close together, down to 20 nanometers apart. When a voltage is applied, electrons surge towards one of the plates, where they form a nanoplasma. Once the voltage reaches a certain threshold, the electrons are emitted almost instantly to the second plate. This rapid movement enabled by such fast switches creates a high-intensity pulse that produces high-frequency waves. Conventional electronic devices are only capable of switching at speeds of up to one volt per picosecond -- too slow to produce high-power THz waves. The new nanodevice, which can be more than ten times faster, can generate both high-energy and high-frequency pulses. The technology could have wide-ranging applications beyond generating THz waves [2].

THz sources could revolutionize security and medical imaging systems. What's more, their ability to carry vast quantities of data could hold the key to faster wireless communications. That’s why nowadays a lot of attention is paid to such unexplored and rarely used types of electromagnetic radiation.

References:
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