

Preface

The range of the electromagnetic spectrum beyond the well-established telecom domain offers a huge potential for practical applications in many different disciplines. In 2004, the Massachusetts Institute of Technology (MIT) identified “THz technology within the ten technologies which will revolutionize our life”. The NATO Workshop “TERA–MIR 2009: International Workshop on Terahertz and Mid Infrared Radiation: Basic Research and Applications” focused on stimulating substantial advances concerning emitters and detectors of terahertz (THz) i.e. 0.3–10 THz (in wavelength from 1000 to 30 μm) and mid infrared (MIR) radiation, i.e. 15–120 THz (from 20 to 2.5 μm). The full use of these spectral regions in applications is only possible with optimum generation and detection of MIR and THz radiation, both representing challenging research in fundamental science and technology. Therefore, this workshop was intended to jointly focus on the development, realization and applications of MIR/THz emitters and detectors by taking advantage of the superior properties of semiconductor materials and lasers and to beneficially exploit their common aspects within a synergetic approach.

Many substances exhibit rotational and vibrational transitions in this region, hence giving access to a spectroscopic analysis of a large variety of molecules which play a key role in security as well as various other areas, e.g. air pollution, climate research, industrial process control, agriculture, food industry, workplace safety and medical diagnostics can be monitored by sensing and identifying them via MIR and THz absorption “finger prints”. Most plastics, textiles and paper are nearly transparent for THz radiation. Therefore, illegal drugs or explosives can be detected by their characteristic absorption spectra at THz frequencies with high selectivity and resolution in applications fields as industrial quality inspection control, customs inspection and security screening.

Moreover, MIR and THz radiation has no endangering effects on human beings and enables higher contrast for “soft matter” than X-rays. In comparison to standard optical technologies for wavelengths up to about 2 μm , sources and detectors for MIR and THz have not yet reached this level of maturity and there is still a large gap for features like wavelength tunability, spectral purity, high power and room

temperature operation, which all are necessary for commercial applications. Plastic or ceramics are detected by X-rays very poorly especially against a background of human body. Unlike X-rays, THz (or T-wave) is not a dangerous radiation, and in some cases T-wave sensors can reveal not only the shape of a hidden object but also its chemical composition. This unique combination of traits make T-waves perfect for effective applications like explosive detection, and security applications. Besides, γ -rays have high resolution in 3D space in case of THz ultrashort pulses.

The possibility to analyze chemical composition of substances by spectroscopic methods is of big interest. Even in case if the substance is in the plastic tank or under the cloth. However, there are many open problems on the path to practical and routine use of THz. Different possible solutions for those problems were discussed during the Workshop.

Presentations and discussions provided during the workshop in the frontier of Terahertz and Mid Infrared basic science and applications can potentially stimulate joint research and projects for designing new materials and devices. The workshop characteristic feature was a stronger emphasis on the mathematical and physical aspects of the research, together with a detail analysis of the application problems. The presentations and discussions allowed an interesting forum for discussion, towards unifying these two spectral domains (THz and MIR) from their common aspects of sources, detectors, materials and applications and discuss key interdisciplinary topics. In this common sense THz and MIR are considered jointly, the driving force for both regimes being applications, however, strongly motivated by fundamental physical and technological challenges.

The main THz and MIR source is the quantum cascade laser (QCL). A strong emphasis was given to invited talks from leading scientists related devoted to turn this advanced technology into affordable commercial devices throughout the THz and MIR spectral ranges and exploit their enormous potential for security applications. However other alternative to THz QCLs were presented, e.g. frequency multiplication using semiconductor superlattices and amplifiers, THz Difference-frequency Generation in Quantum Cascade Lasers (generating THz from efficient MIR QCLs), Sub-Terahertz Imaging From Avalanching GaAs Bipolar Transistors, mm-Wave Signal from phase-Locked DFB via Four Wave Mixing, Josephson Junctions as THz sources, Clinotrons as THz sources, Semiconductor materials for pulsed THz sources, Superconducting THz electronics with Josephson vortices.

Details of state of the art THz and Mid Infrared detection have been given as well as progress towards integration of THz devices in microchips. Detection of explosives and other substances have been analyzed as well integration with fibres and the interaction of THz radiation of biomaterials. Advanced theoretical simulation methods and out of the box solutions for QCLs have been discussed including lasing without inversion. Furthermore detailed studies of fundamental physics related to intersubband optics (e.g. intersubband polaritons were presented). Metamaterials have also been discussed in both millimetre wave and THz ranges.

In summary this meeting allowed the attendees to get a global picture of the state of the art in TERA-MIR generation, detection and applications. We had an excellent opportunity to discuss further proposal possibilities and I hope that a few meaningful collaboration projects will be submitted after this meeting.

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