50 years of the Institute of High Pressure Physics Polish Academy of Sciences

Highlights in III-V semiconductors, THz physics and nanomaterials

Anniversary Symposium „Unipress 50"

Revolution in THz world

prof. Wojciech Knap, prof. Tomasz Skotnicki, prof. Alvydas Lisauskas, prof. Dmytry Lyubchenko, prof. Marek Potemski, Katarzyna Kołys

ERC ADVANCED GRANT

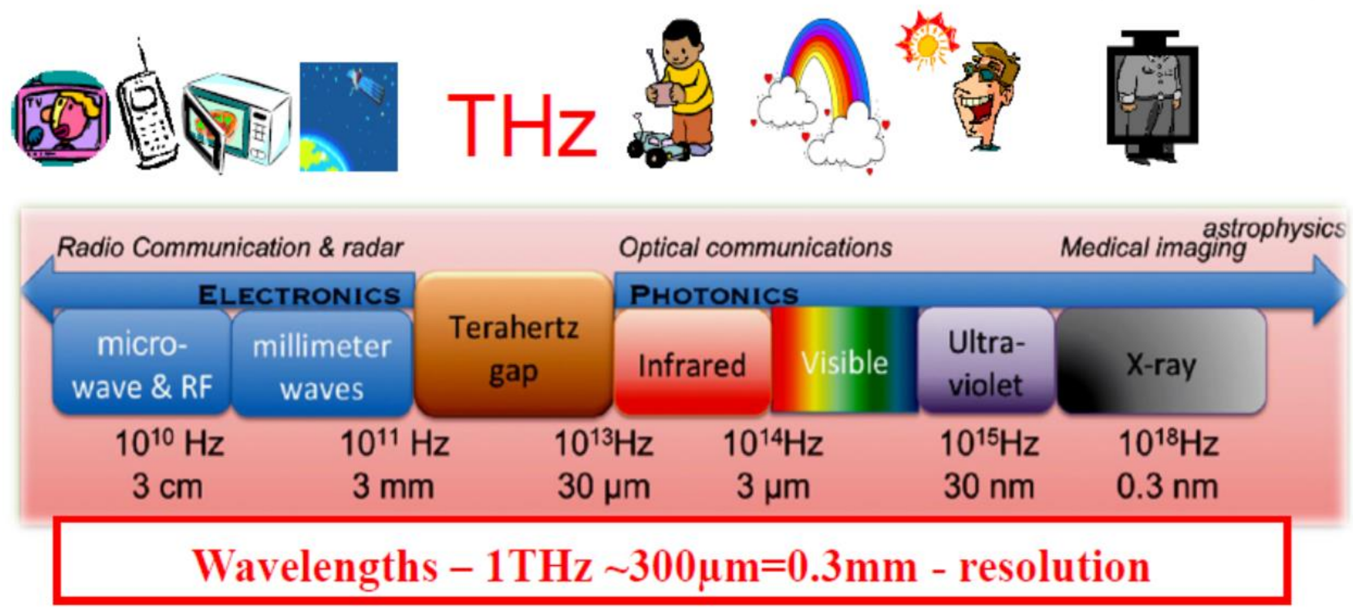
ERC is the most prestigious grant competition in Europe. So far, only six ERC Advanced grants were granted to Poland.
The TERAPLASM project applies to the research on electromagnetic waves of very high frequency, in the range of terahertz (THz is 10^{12} Hz).

Prof. Wojciech Knap received ERC Advanced Grant

TERAHERTZ RADIATION

THz radiation (also called T-waves, THz, or sub-millimeter THz radiation) is electromagnetic radiation within the frequency bands around 10^{12} Hz. The name refers to the frequencies between infrared light and microwaves. Even if THz radiation was discovered a long time ago, it still has remained unused on a mass scale. This is the reason, why it is also known as "the forgotten band". It provides a huge potential for applications.

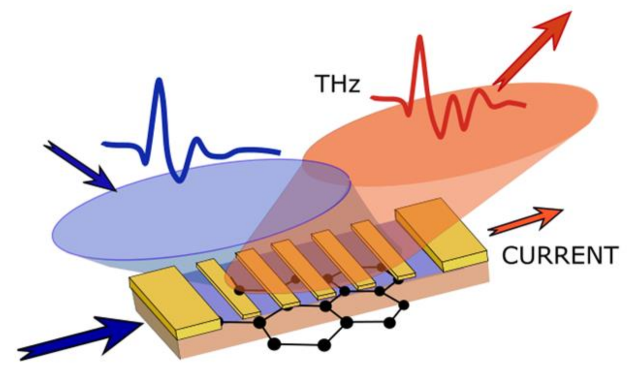
Courtesy, Prof. T. Otsuji



TERAPLASM

The package of innovative plasmonic research activities proposed by prof. Knap was appreciated by the ERC Council.
The TERAPLASM project applies to the research on electromagnetic waves of very high frequency, in the range of THz that is even a thousand times higher than the frequency range used in the modern wireless communications or WiFi.

Such high frequency electromagnetic waves could find a use for the future communications, imaging systems, health monitoring and detection of chemicals, but in this frequency range we haven't have effective and cheap solutions available, allowing for the mass application in the industry and everyday life because we can't overcome fundamental physical and microelectronics barriers.



Scheme of grating gate of THz emiter based on low-dimensional structure.

IRAP CENTERA

CENTERA is an R&D center implemented under the programme International Research Agendas Programme (IRAP) - with the ambition to become Centre of Excellence in Terahertz Science and Technology.

CENTERA sets out to develop breakthrough technologies in the field of THz generation, processing, emitting, and reception. The novel THz sources and other technological advancements from CENTERA will enable the utilization of THz waves in various areas.

Prof. Wojciech Knap, WP1

Prof. Marek Potemski, WP2

Prof. Alvydas Lisauskas, WP3

Prof. Dmitry Lyubchenko, WP4

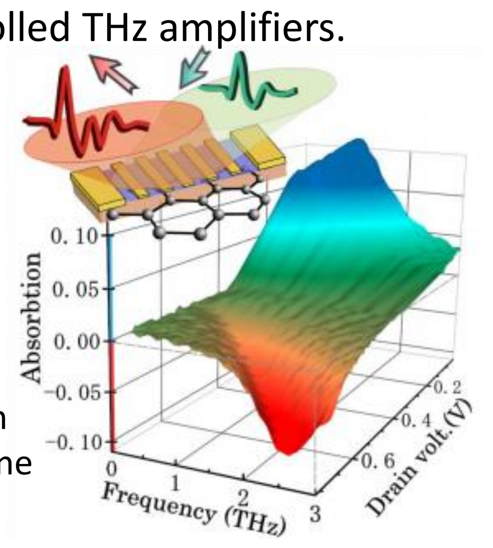
Prof. Thomas Skotnicki, WP5

The „Center for Terahertz Research and Applications (CENTERA)" project is carried out within the 'International Research Agendas' programme of the Foundation for Polish Science co-financed by the European Union under the European Regional Development Fund.

PHYSICAL REVIEW X

The discovery of amplifying of THz radiation at the room temperature by graphene nanostructures was published in a prestigious magazine industry-specific Physical Review X!
Researchers from CENTERA and Tohoku University in Japan explored THz light-plasmon coupling, light absorption, and amplification in a graphene-based system, whose excellent room-temperature electrical and optical properties are ideal for solving this problem. Using monolayer graphene grating gate structures, we demonstrate tunable resonant plasmon absorption which, with an increase of the current, turns to THz radiation amplification. The observed gain of up to 9% is far beyond the well known landmark level of 2.3% that is maximal available in monolayer graphene when photons directly interact with electrons.

To interpret our results, we used a dissipative plasmonics crystal model, which captures the main trends and basic physics of the amplification phenomena. Specifically, the model predicts that increasing current drives the system into an amplification regime, wherein the plasma waves may transfer energy to the incoming electromagnetic waves. All results were obtained at room temperature. Therefore, our experimental setup paves the way toward future THz plasmonic technology with a new generation of all-electronic, resonant, voltage-controlled THz amplifiers.

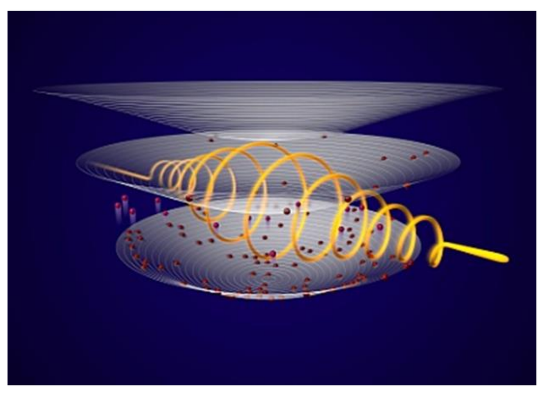


Absorption to Amplification of THz radiation by Graphene Grating Gate Transistors

NATURE PHOTONICS

An international team of researchers has now taken an important step in the right direction: In the journal Nature Photonics they described a material that generates terahertz waves by simply applying an electric current.
The "Landau-level laser" is an exciting concept for an unusual radiation source. It has the potential to efficiently generate so-called terahertz waves, which can be used to penetrate materials as well as for future data transmission. So far, however, nearly all attempts to make such a laser reality have failed. An international research team has been able to show that it is relatively easy to generate terahertz waves with an alloy of mercury, cadmium and tellurium.

To examine the behavior of the electrons in the material, the physicists use the free-electron laser FELBE at HZDR. Circularly polarized terahertz pulses (orange spiral) excite the electrons (red) from the lowest to the next higher energy level (parabolic shell). The energy gap of these so-called Landau levels can be adjusted with the help of a magnetic field.

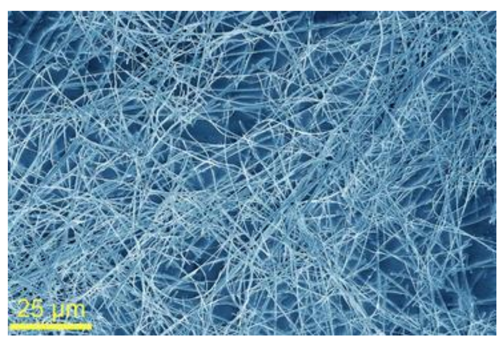


HZDR / Juniks

ADVANCED MATERIALS

Engineers from the University of California, at Riverside and CENTERA researchers described a flexible film using a quasi-one-dimensional nanomaterial filler that combines excellent electromagnetic shielding with ease of manufacture.
The results were amazing: no electric conductivity but more than 99.99% of EMI shielding for micrometer thick films.

These novel films are promising for high-frequency communication technologies, which require electromagnetic interference shielding films that are lightweight, corrosion resistant, cheap, electrically insulating.



One-dimensional $TaSe_3$ nanowires used to fill an EMI-shielding polymer film. (Zahra Barani).

OTHER CENTERA ACHIEVEMENTS

- Stanford University listed Prof. Wojciech Knap and prof. Thomas Skotnicki among The World's Top 2% Scientists.
- CENTERA THz Days under the Patronage of French Embassy, awarded with status Official Event of Polish-French Science Year.

Second place at Smart City Hackaton awarded to CENTERA team led by Katarzyna Kołys.

FNP START competition "Mazovian Innovator" 2 awards for PhD Aleksandra Krajewska from WP4.

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