Terahertz Plasma Wave Instabilities in GaN/AlGaN Nanowires

At the beginning of the 1990s, theoreticians predicted that nanometer (1nm = 10^{-9} m) semiconductor structures (such as the field effect transistors studied in the project) could act as a radiation source with a frequency in the terahertz range (THz = 10^{12} Hz). This radiation is harmless to humans, and it can penetrate materials such as clothes, plastics or bricks. Theoretical predictions were confirmed experimentally in the early 2000s. Practically the most useful are signals with a precise frequency (resonances), the value of which can be varied in a wide range (tunable), eg by changing the applied voltage. Unfortunately, both parameters of the emission signals observed at that time were significantly worse than those predicted theoretically. Our project aims to significantly improve this situation by **processing and testing a special kind of semiconductor nanostructures (transistors)** that will be able to operate **as tunable and resonant terahertz radiation sources (THz).**

The scope of research: THz radiation has a wavelength between microwaves and infrared light (such as in TV remote controls). Due to the fact that it is harmless to humans, and at the same time penetrates through clothing, plastics, suitcases, bricks and other various types of dry items, it can be used to screen passengers at airports, postal items, or used in production control without destroying packaging.

The object of research: transistors are very small electronic elements that control the flow of current and constitute the basic component of every electronic device. The technology for producing transistors on silicon is very well developed, and the transistors themselves are common.

The material: GaN, or gallium nitride, is a semiconductor material, like more popular silicon, but with some other physical properties. Thanks to him, white LEDs shine. Transistors made on this material are characterized by high resistance to temperature, voltage and harmful chemical factors. Poland, and in particular the institute implementing the project - UNIPRESS (ie the Institute of High Pressure Physics PAS) - has a particularly rich experience in the production and testing of this material. It was there that was created, among others Polish blue laser. The Institute belongs to the forefront of research units in Poland (has the scientific category A +).

The project is carried out **jointly with a partner from Lithuania**, the State research institute Center for Physical Sciences and Technology (FTMC). It has the perfect measuring equipment necessary for our research. This is where we will take measurements. On the other hand, the Polish partner is a specialist in producing needed transistors. The benefits of cooperation will therefore be mutual.

Thanks to the project, we will ultimately decide whether the theory describing the mechanism of generating terahertz radiation in transistors is correct. This theory predicts several phenomena that we should observe thanks to our novel transistor design as well as through the use of excellent material quality - GaN. Our research should also allow the generation of nanotransmitters with a large, more usable and wider range of applications, including THz spectroscopy, imaging in the field of safety, quality control and medical applications, and thus they can have significant economic and social impact in the future.