WITH: WIreless communication using TeraHertz plasmonic-nano ICT devices

The Japanese-French initiative on plasmonic nano-device technologies for ultra-broadband wireless communications using "terahertz" waves

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The strongly increasing demand for higher-data-rate wireless communication owing to the trend of a ubiquitous ICT society has led us to explore new frequency resources higher than any existing wireless communication band, approaching "terahertz (THz)" or 1000 GHz. For example in the very near future super-HDTV will become available for which over 40-Gbit/s wireless transmission over carrier frequencies of 400GHz and higher will be needed. THz and sub-THz waves can be considered for a wide aspect of last-mile, short-distance free-space high data-rate communication purposes using a several existing atmospheric windows with low attenuation (0.1dB/10m). However the feasibility of very high data-rate transmission with sub-THz to THz carrier is still an open question. There are two main problems: i) how to generate and modulate the sub THz signals, and ii) how to detect them. **Showing the feasibility and demonstrating the first high data rate ~40-Gbit/s communication prototypes at unexplored frequency range from 400 to 900 GHz by testing and improving existing devices and developing novel plasmonic nano-devices is the main goal of this 'WITH' project.**

In order to break through the speed limit of conventional carrier transit-type electron devices, we considered THz plasma oscillations in the 2D (two-dimensional) in nanostructures as a new physical mechanism of operation to realize i) frequency-tunable, room-temperature operating coherent monochromatic THz sources, ii) fast, detection of coded THz carrier waves, and iii) 10-40-Gbit/s intensity modulators for sub-THz and THz carrier signals. The fundamental structure of those devices was based on the nanometer high electron mobility transistors (HEMT's) and applicant's original dual-grating-gate (DGG) HEMT strucures. Novel advanced device structures integrated with antennas were developed and integrated into the real devices/demonstrators. We developed also new/improved models of the most competitive existing THz sources based on the use of UTC-PD's (Uni-Travelling Carrier PhotoDiodes) as an alternative existing reference standard of state-of-the-art technology. Real test-bed sub-THz and THz wireless transmitter/receiver frontend devices were designed and integrated to demonstrate up to 40-Gbit/s class wireless communication, verifying the feasibility of the ultra-broadband THz wireless communications under a complementary, co-lateral collaboration between Japanese and French teams.

The major achievements on this JST-ANR WITH project are (i) the development of ultrahigh-sensitive broadband plasma-wave detectors featured by a newly-invented asymmetric dual-grating gate (A-DGG) structure, and (ii) Building up 200-720-GHz class wireless communication test systems demonstrating world-record 40-Gbit/s error-free transmission of HDTV signals using THz frequencies.

The project accompanied/reinforced international research network (GDRI) with many other partners from Poland, France, Japan and Russia, leading to creation of EU founded COST action MP1204 **TERA-MIR Radiation: Generation, Detection and Applications.**

[1] Sci. Technol. 3, 63 (2013); W. Knap et al Nanotechnology 24, 214002(2013), S. Blin et al., IEEE Electron Device Lett. 33, 1354 (2012) ; J. Oden et al., Opt. Exp. 21, 4817 (2013) ; T. Nagatsuma et al., Opt. Exp. 21, 23736 (2013).

Illustration

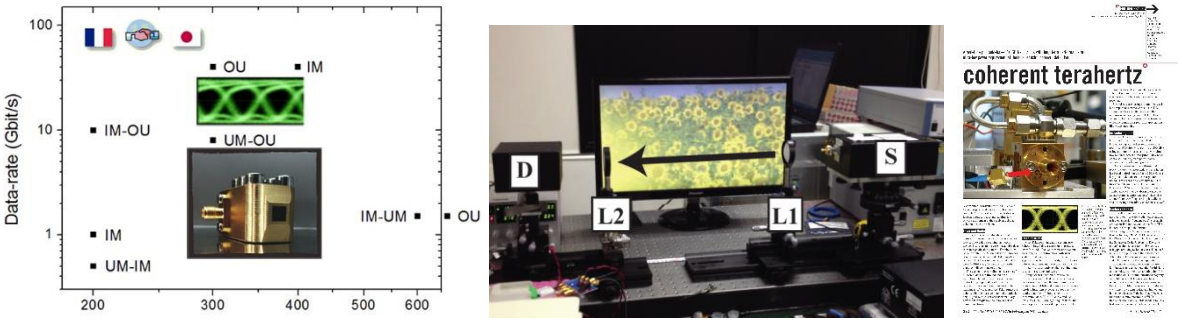

Fig. 1. Left:. benchmarking the WITH project achievements for data rate vs. carrier frequency. Center : photograph of the uncompressed HD video transmission showing the frequency-multiplied source on the right, the plasma-wave receiver on the left (inside its electromagnetic shielding box), and two Teflon lenses in between for collimating and focusing. The source amplitude is modulated by a real-time high-definition and uncompressed video signal. Transmitted signal is observed on the TV screen at the background. Right: latest publication in IEE Electronice Letters has been highlighted as a “Featured Issue” of an excellent France-Japan collaborative work.

Factual information

The WITH project was an experimental research project exploring the limits of wireless communication using innovative technologies. It was coordinated by W. Knap (CNRS – Montpellier) in France and by T. Otsuji (Tohoku University) in Japan. It was associated with 3 French laboratories from CNRS-Univ. Montpellier (Montpellier), IEMN (Lille) and Univ. Savoie (Chambery), as well as 3 Japanese laboartories from Tohoku University (Sendai), Osaka University (Osaka), and RIKEN (Sendai). The project started on November 2010 and lasted 36 months. ANR grant amounted to 969,996 € (135.8 M¥) and JST grant amounted to 141 M¥ (1,007,142 €) for a total budget of 1,977,138€ (276.8 M¥) at an exchange rate of 1 € = 140 ¥.