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# Extreme-performance diagnostics in time-and-space for sources emitting terahertz transients

[1] Organization

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[2] Research Progress

The research objective is to explore new methods (extreme-performance imaging) and for short times (e.g., EO-sampling, streaking techniques, terahertz diagnostics). The period of the collaborating research project: 2015 May 29 to 2016 March 6.

The department of Accelerator Research at KIT is exploring new ways to detect single short electron bunches consisting of relativistic electrons by direct diagnostics or indirectly via the short emitted photon pulses consisting of THz transients in the sub-ps to fs time scale. This requires extreme-performance diagnostics for new generations of electron accelerator-based sources. FLUTE (Ferninfrarot Linac- Und Test Experiment) is a linear accelerator-based (linac) and test experiment for accelerator research and technology, currently under construction at KIT, which is planned to provide short pulses, initially tens of fs within the next year 2016, with the goal to reach ultimately 1 fs and with very high intensity and electric fields potentially in the GV/m range with emission frequencies, initially, in the terahertz frequency range.

The intention of the collaborative research is to explore and develop new detection and imaging technologies in the terahertz range at RIE at Shizuoka University, which can be employed at the FLUTE facility at KIT for diagnostics and as proof-of-principle for such radiation sources.

The short pulses in the time-domain and subsequently broad spectral coverage in the frequency-domain suggest that array technology with a pre-set splitting of spectral components by a grating or by filters or antennas directly mounted on each pixel element, similar to a filter bank, are most suitable, for details see publication (1) listed under section [4] of this report.

[3] Results

(3-1) Research results

Within the research period E. Bründermann, H. Inokawa and N. Hiromoto in Shizuoka University, explore scientific concepts to detect single short pulses from sub-ps to the fs timescale and possibilities to image short terahertz transients and signatures in time and space.

Initial discussions showed that very short transients could be mapped form the time domain to the frequency domain, which could be

measured by a detector line array. The detector elements will be developed and tested by the collaborators at Shizuoka University. He and collaborators in Shizuoka University do basic experiments on terahertz imaging, detector performance and have meetings to discuss the new techniques for diagnostics and imaging in time-and-space for sources emitting terahertz transients.

For the purpose of a personal exchange E. Bründermann visited the Research Institute of Electronics during the period from Aug 30th to Sep 5th, 2014.

Also during the visit the collaborators presented and published, in form of extended Abstracts and presentations, discussion points and initial results within the FTT2015 symposium held at Hamamatsu, see publications (1) and (2) listed under section [4] of this report.

(3-2) Ripple effects and further developments

If more final new results of the research on imaging of terahertz transients manifest, then they will be published as an academic journal paper. It is expected to develop suitable detectors for the research goals, initially during the research period, one high-performance terahertz detector.

In continuing research periods it is expected to develop two detectors for balancing measurements and an initial small line array. It is also expected, at a later stage, to employ these detectors at the FLUTE facility at KIT and test their performance. The scientific discussions are expected to lay the ground for negotiations of a longer term collaborative research to develop new types of diagnostics for electron accelerator and short pulse terahertz photon sources.

The collaborative work in this program includes discussions to negotiate an agreement on academic exchange and cooperation in form of a Memorandum of Understanding (MOU) between Karlsruhe Institute of Technology (KIT), Germany, and Shizuoka University, Japan, including the Institute for Photon Science and Synchrotron Radiation (IPS) and the Research Institute of Electronics (RIE).

[4] Achievements (List of Publications)

(1) E. Bründermann, A.-S. Müller, H. Inokawa and N. Hiromoto, "Terahertz diagnostics of ultra-short pulses at high repetition rates from relativistic electron sources," The Second International Symposium on Frontiers in THz Technology(FTT2015), (Congress Center in ACT CITY Hamamatsu, Japan), TuA1.4 (September 2015).

(2) T. Ueta, Y. Suzuki, H. Satoh, A. Tiwari, N. Hiromoto, E. Bründermann, H. Inokawa, "Study of THz Antenna-Coupled Bolometer utilizing SOI MOSFET," The Second International Symposium on Frontiers in THz Technology(FTT2015), (Congress Center in ACT CITY Hamamatsu, Japan), Pos1.33st (September 2015).

*Further Achievement*: Signing of MOU between Karlsruhe Institute of Technology (KIT), Germany, and Shizuoka University, Japan, final signature on November 24th, 2015.

*Announcement on KIT website in section on International Affairs*: "Cooperating with Japan", http://www.intl.kit.edu/ischolar/8214.php

Travelling Report (Mention each travel by CRP budget.)

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Period of time : From Aug. 28, 2015 to Sep. 5, 2015

Destination : Shizuoka University, Hamamatsu Campus, RIE

Purpose : Collaboration on research of extreme-performance diagnostics in time-and-space for sources emitting terahertz transients and discussion on Memorandum of Understanding between Karlsruhe Institute of Technology and Shizuoka University.

The research objective is to explore new methods for terahertz diagnostics in space (extreme-performance imaging) and for short times (e.g., EO-sampling, streaking techniques, terahertz diagnostics). The department of Accelerator Research at KIT is exploring new ways to detect single short electron bunches consisting of relativistic electrons by direct diagnostics or indirectly via the short emitted photon pulses consisting of THz transients in the sub-ps to fs time scale. This requires extreme-performance diagnostics for new generations of electron accelerator-based sources.

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Name of receiver : Norihisa Hiromoto, Shizuoka University