

Project No. : P-49 (font: 12 points and bold)

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

[1] Organization (10.5 points)

Project Leader (PL) : Dr. Bründermann, Erik
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Representative at RIE : Prof. Inokawa, Hiroshi
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Participants : Prof. Hiromoto, Norihisa
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[2] Research Progress (10.5 points)

This new research project has been started on May 30th, 2014 with discussions between KIT and SU on a plan of the research for 2014 Cooperative Research Projects at RIE by e-mail. The collaborative works of the research have been carried out with a visit of Dr. Bründermann from KIT at RIE and the Hamamatsu Campus in the period from Nov 3rd to Nov 20th, 2014. The research objective is to explore new methods for terahertz diagnostics in space (extreme-performance

imaging) and for short times (e.g., EO-sampling, streak-techniques, terahertz diagnostics) in the context of "*Projects on the imaging with extremely high performance concerning the sensing in invisible region*". The department of Accelerator Research at KIT led by the PL 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 sources, currently under construction at KIT, which will provide short pulses, initially tens of fs, with the goal to reach 1 fs and with very high intensity and electric fields in the GV/m range.

The PL, H. Inokawa and N. Hiromoto in Shizuoka University discussed 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.

[3] Results (10.5 points) (3 - 1) Research results

The research subsidy of JPY 285,000 allowed Dr. Erik Bründermann to travel to RIE and to have personal scientific discussions with Prof. Hiroshi Inokawa, Assistant Prof. Hiroaki Satoh and Associate Prof. Ohki Kambara of RIE, Prof. Akihiro Ishida of Graduate School of Engineering, and Prof. Norihisa Hiromoto of GSST in the meeting after the seminar to professors and students of the Graduate School of Science and Technology.

Dr. Bründermann presented in a seminar the challenges of the research project and possible first solutions. It is envisioned to test first single detectors fabricated at Shizuoka University by

the project participants with radiation sources at KIT.

Based on a previous collaborative work, discussions supported by RIE [see acknowledgment in Ref1] and joint publication [Ref2] it might be feasible to use optimized terahertz line arrays as part of a grating or dispersive spectrometer or by frequency selective pixels with different sensitivity at different terahertz frequencies.

These could be used as a spectrometer to reconstruct the pulse shape and length via the spectral content. In general, concepts of mapping time information to the spectral domain (short pulses lead to a broadband terahertz spectrum) and, subsequently, mapping spectral ranges to spatial areas on a pixelated detector could be a possible realization for the detection of ultra-short pulses.

Using in the next extension the 2nd dimension for imaging terahertz sensors would be a further goal to allow beam profiling and mapping and diagnostics of quasi-optical beam transport from the terahertz generation zone of the electron beam to the station for terahertz experiments with the delivered radiation and would also allow investigating the electron beam properties.

[Ref1] S. Funkner, G. Niehues, D.A. Schmidt, E. Bründermann, Terahertz Absorption of Chemicals in Water: Ideal and Real Solutions and Mixtures, *Journal of Infrared, Millimeter, and Terahertz Waves* 35(1), 38-52 (2014).

[Ref2] H.-W. Hübers, M. F. Kimmitt, N. Hiromoto, E. Bründermann, Terahertz spectroscopy: system and sensitivity considerations, *IEEE Transactions on Terahertz Science and Technology*, 1(1), 321-331 (2011).

(3 – 2) Ripple effects and further developments

In addition, a first draft of a Memorandum of understanding (MOU) between KIT and Shizuoka University was prepared and first meetings and discussions during the visit of Dr. Bründermann at Shizuoka University took place with Prof. Hidenori Mimura and Prof. Takeshi Sako. We expect that in due time a MOU could be formed to allow mutual exchange of researchers

and students to intensify the research collaboration beyond the current state.

[4] Achievements (List of Publications) (10.5 points)

The research project has started as a New Project in November 2014, however, we expect in due time joined publications between the projects participants, as has been demonstrated previously by publication in internationally peer-reviewed journals (see [Ref2] above) and explicit acknowledging support by RIE in internationally peer-reviewed journals (see [Ref1] above).

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Travelling Report (Mention each travel by CRP budget.)

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Period of time : 2014-11-03 to 2014-11-20

Destination : Shizuoka University, Hamamatsu Campus, RIE

Purpose : Dr. Bründermann is a Honorable Guest Professor (HGP) of Shizuoka University since April 2009 until today and has visited RIE in the framework of the Project No. P-49. The subsidy for travel expenses within Project No. P-49 partially supported the visit indicated above to start the research project and allow scientific discussions and planning of next steps.

Name of receiver : Prof. Norihisa Hiromoto