Available online at www.sciencedirect.com

ScienceDirect

Physics Procedia 84 (2016) 152 – 156

Physics Procedia

International Conference "Synchrotron and Free electron laser Radiation: generation and application", SFR-2016, 4-8 July 2016, Novosibirsk, Russia

First terahertz-range experiments on pump – probe setup at Novosibirsk free electron laser

Yulia Yu. Choporova[a,b]*, Vasily V. Gerasimov[a], Boris A. Knyazev[a,b]†, Sergey M. Sergeev[c], Oleg A. Shevchenko[1], Roman Kh. Zhukavin[c], Nikolay V. Abrosimov[d], Konstantin A. Kovalevsky[c], Vladimir K. Ovchar[a], Heinz-Wilhelm Hübers[e,f], Gennady N. Kulipanov[a], Valery N. Shastin[c], Harald Schneider[g] and Nikolay A. Vinokurov[a]

[a]*Budker Institute of Nuclear Physics, Novosibirsk, 630090 Russia*
[b]*Novosibirsk State University, Novosibirsk, 630090 Russia*
[c]*Instutute for Physics of Microstructures, Nizhny Novgorod , 603950 Russia*
[d]*Leibniz Institute of Crystal Growth, Berlin, 12489 Germany*
[e]*Humboldt-Universität zu Berlin, Berlin, 12489 Germany*
[f]*DLR Institute of Optical Sensor Systems, Berlin, 12489, Germany*
[g]*Helmholtz-Zentrum Dresden-Rossendorf, Dresden, 01314 Germany*

Abstract

A single-color pump-probe system has been commissioned at the Novosibirsk free electron laser. The laser emits a tunable monochromatic terahertz radiation. To prove the proper system operation, we investigated the time-resolved absorption of a sample of n-type germanium doped with antimony, which was previously investigated at the FELBE facility, in the temperature range from 5 to 40 K. The measured relaxation time amounted to about 1.7 ns, which agreed with the results obtained at the FELBE. The results of pump-probe measurements of non-equilibrium dynamics of hot electrons in the germanium crystal at cryogenic temperatures are presented for wavelengths of 105, 141 and 150 μm.

* Corresponding author. Tel.: +7-913-383-4346;
*E-mail address:*yu.yu.choporova@inp.nsk.su
† Corresponding author. Tel.: +7-913-945-4445;
*E-mail address:*b.a.knyazev@inp.nsk.su

Peer-review under responsibility of the organizing committee of SFR-2016.
doi:10.1016/j.phpro.2016.11.027

Peer-review under responsibility of the organizing committee of SFR-2016.

Keywords: free electron laser, pump-probe spectroscopy, terahertz radiation, semiconductor

1. Introduction

Study of fast processes with high temporal resolution is one of the important problems in the modern science, and the pump-probe technique is a powerful method for solving this task. This technique can be implemented in different variants: the pump pulse and the probe pulse have different wavelengths or, alternatively, the same pulse split with a beam splitter is used for both the pump and probe radiations. Most pump-probe experiments in the terahertz spectral range were carried out using the time-domain technique, in which the pump radiation has an extremely wide spectral width. As an example we can mention the paper by Hoffmann et al. (2009), in which a THz pump – THz probe time-domain experiment is described. In certain cases, however, when excitation of selected levels is required, it is necessary to apply systems with monochromatic pump radiation. Since sources in such experiments are required to have a high pulsed power and a narrow linewidth, as well as radiation wavelength tuning within a wide spectral range, free electron lasers are devices meeting these criteria well.

The pump-probe technique is widely used for study of semiconductors. In paper Deßmann et al. (2015) TEMP per by the recombination time of extrinsic Ge photodetectors was measured in a single-color pump-probe system, which operates at the free electron laser FELBE (Helmholtz Zentrum Dresden-Rossendorf). Now, a similar THz pump – THz probe system is being commissioned at the Novosibirsk free electron laser (NovoFEL) (Kulipanov et al., 2015) at Budker Institute of Nuclear Physics SB RAS.

NovoFEL is a user facility consisting of three laser systems emitting monochromatic high-power radiation in spectral ranges from 5 to 240 μm. The first THz laser system has been in operation since 2003. It emits radiation as a continuous stream of 100-ps pulses with a repetition rate of 5.6 MHz in the spectral range from 90 μm to 240 μm. The average power of the laser beam reaches 500 W at a repetition rate of 11.5 MHz. In a routine regime, the average power of radiation at the user stations is 50-100 W at $\lambda = 130$ μm and $f = 5.6$ MHz.

2. Experimental setup

The equipment of Siberian Center for Synchrotron and Terahertz Radiation was used in the experiments performed. A schematic representation of the pump-probe system is shown in Fig. 1.

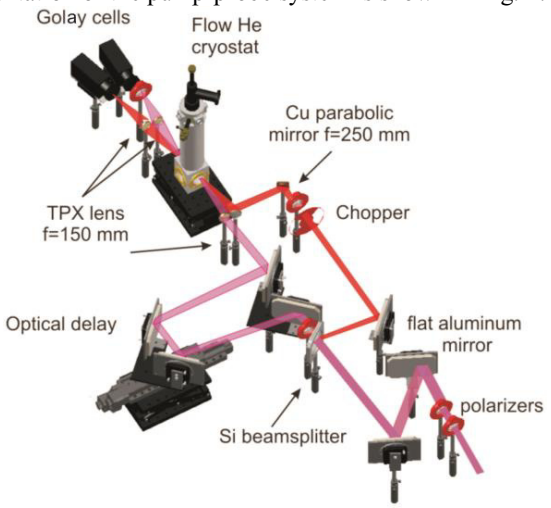

Fig. 1. Schematic presentation of single-color pump-probe setup at NovoFEL facility. Red line: pump beam, purple line: probe beam.