NovoFEL – tunable high power source of terahertz radiation: new results and perspectives

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Abstract — Status of NovoFEL with planned range of wavelength from 240 to 5 μm based on four-track energy recovery linac with maximum energy 40 MeV is described. Experimental results of using of high power THz radiation in physics, chemistry, biology are presented: ultrasoft THz ablation of biological substances; plasmon spectroscopy of surfaces and films; time-resolved superfast time domain spectroscopy; flame diagnostics.

Keywords — free electron laser; energy recovery linac; THz radiation; THz spectroscopy; THz ablation.

Novosibirsk free electron laser (FEL) facility has three FELs to generate radiation spanning a wavelength range between 5 and 240 micrometer. The accelerator part consists of a four-track energy recovery linac with maximum electron energy of 40 MeV. By the end of 2012 we have commissioned completely the accelerator system. Two FELs are already operating in mid- and far-infrared (terahertz) spectral ranges emerging monochromatic radiation in the range from 50 to 240 μm. Maximum average power of radiation reached at the facility at the wavelength of 140 μm was 500 W at a 100-ps pulse repetition rate of 11.2 MHz. The peak power reached 1 MW [1-4].

<table>
<thead>
<tr>
<th>Status</th>
<th>1st stage (1 track)</th>
<th>2nd stage (2 track)</th>
<th>3rd stage (4 track)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength, μm</td>
<td>110 - 240</td>
<td>40 - 80</td>
<td>5 - 20</td>
</tr>
<tr>
<td>Relative line width, %</td>
<td>0.2 - 2.0</td>
<td>0.2 – 1.0</td>
<td>0.1 – 1.0</td>
</tr>
<tr>
<td>Maximum average power, MW</td>
<td>0.5</td>
<td>0.5 – 1</td>
<td>10</td>
</tr>
<tr>
<td>Pulse duration, ps</td>
<td>30 - 120</td>
<td>20 - 40</td>
<td>10 - 20</td>
</tr>
</tbody>
</table>

Pulse repetition rate is 2.8 or 5.6, 11.2, 22.4 MHz, linear polarization degree of radiation more than 99.6 %. The power and relative line width obtained in the terahertz range (the 1st stage) are record parameters.

Impressive experiments in physics, chemistry, biology, material science and other fields have been performed or are in progress at six user stations, which are well-equipped with commercially available and home-made instrumentation. Users from more than 15 research institutes, universities and companies work at the facility. The themes of works using NovoFEL THz radiation in 2012-2013:

- Ultrasoft ablation with powerful THz radiation.
- Study of the impact of THz radiation on genetic material.
- Exploration of the impact of THz radiation on stress-sensitive biological cell systems.
- THz radiation influence of the katG and E.coli dps genes.
- Study of the integrated proteomic response of E.coli to exposure by terahertz radiation.
- Experiment with THz pumping and detection by EPR.
- Ultrafast high-resolution THz time-domain spectroscopy.
- Speckle photography and speckle interferometry.
- Spectroscopy of attenuation total reflection (ATR) and plasmon spectroscopy of surfaces and films.

Description of most interesting experiments, including ultrasoft THz ablation of biological molecules, study of impact of THz radiation on genetics materials, biological cell systems and microorganisms, surface plasmon spectroscopy, time-resolved superfast THz time domain spectroscopy, flame diagnostics using THz radiation, is presented.

REFERENCES