Establishment of a free electron laser-based user facility for IR-THz spectroscopy at RRCAT

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A unique user facility has been established at the Raja Ramanna Centre for Advanced Technology (RRCAT), Indore for the Infrared-Terahertz (IR-THz) spectroscopy of materials under low temperature and high magnetic field sample environment. In this facility, studies can be performed using the intense, coherent, monochromatic and continuously tunable electromagnetic radiation from an infrared free electron laser (IR-FEL), or with broad-band radiation from low power laboratory sources. The IR-FEL delivers an IR beam with a brightness of ~10^{13}–10^{14} photons/s/mm^2/mrad^2/0.1% BW in the wavelength range of 12–54 μm at a custom–built user station, where trial experiments using this light have been started. A custom built Fourier transform infrared spectrometer, working in conjugation with a magneto-optical cryostat system has been commissioned at the user station where the IR-FEL light can be coupled. This is the only working FEL in the country along with its user facility. The present study highlights the latest results from the commissioning of the IR-FEL based user facility, the first-trial experiments performed therein, and the future developmental ideas.

Keywords: Free electron laser, IR-FEL, micropulse, tunability, user facility.

example, the source brightness of Indus-1 near 12 μm is ~10^{10} photons/s/mm^2/mrad^2/0.1% BW, while it is two orders of magnitude higher at the critical wavelength of 61 Å (ref. 1).

The study of materials and chemical/biological samples using far infrared (IR) and terahertz (THz) radiation with wavelengths from ten to hundred sec of micrometres interests many researchers worldwide. This wavelength region falls in the so called THz gap in the electromagnetic spectrum, where conventional sources are either not available or are not very efficient. While novel sources like quantum cascade lasers have been developed to deliver mW level continuous wave (CW) average power at THz wavelengths, these are still evolving in terms of their ability to operate above liquid nitrogen temperatures[2]. Other sources using optical rectification, wave mixing or other electro-optic techniques, or broad band sources like Globar, etc. deliver μW or nW level power, which may not be sufficient for many studies[3]. FELs, on the other hand, are versatile sources with proven ability to deliver MW level peak power and tens or hundreds of mW of CW average power with precise tunability over up to two orders of magnitude in wavelength. They also deliver short pulses of nanoseconds to femtoseconds widths. Several IR-THz free electron laser (FEL) ...