Development of the Far-Infrared Beam Line of Tabletop Synchrotron Radiation Source

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In recent year, it has become apparent that synchrotron radiation (SR) is a useful source in Terahertz (THz) or far infrared spectroscopy (FIRS). Numerous beam lines that are dedicated to infrared spectroscopy have been developed at SR facilities throughout the world. In the far infrared (FIR)/terahertz (THz) region, however, the use of FIRS has been greatly limited because of the lack of brilliant and high flux light sources. The purpose of this study is to develop the highest brightness FIR beam line of synchrotron radiation source. The experimental works were carried at MIRRORCLE-type table-top storage ring at SLLS, Ritsumeikan University. The instrumentations and literature on far-infrared spectroscopy were reviewed. As the MIRRORCLE-20, operating at electron energy Eel = 20 MeV is optimized for FIR beam we performed machine study of this light source in our first step. To clarify the characteristics of this light source, its mid-IR power as well as far-IR spectrum was measured. It was found by studying beam dynamics that the 2/3 resonance injection mode is not suitable for MIRRORCLE-type storage ring due to its large betatron oscillation. As a result, we have switched MIRRORCLE-6X to MIRRORCLE-6FIR, using different mode of beam injection. For this purpose, an exactly circular optics, an important device for this beam line have been designed and fabricated. The optimum optical system was determined by using the ray-trace simulation ZEMAX.

Finally, the performance of MIRRORCLE-6FIR beam line was studied. To illustrate the facility of this light source, FIR output as well as spectrum was measured. The MIRRORCLE-6FIR output is compared with a standard internal thermal source, and is found that it is 1000 times greater than that from a typical thermal source at around 15 cm^{-1}. It is also observed that the MIRRORCLE-6FIR radiation has a highly coherent nature. The broadband infrared allows the facility to reach the spectral range from 10 cm^{-1} to 100 cm^{-1}. MIRRORCLE-6FIR, due to a large beam current, special optical system, a large dynamic aperture, and small ring energy, can deliver a bright flux of photons in the FIR/THz region useful for broadband spectroscopy.