Short-pulse x-ray beams driven by intense laser pulses and their applications

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Abstracts: *Ultrashort x-ray/gamma-rays from laser-plasma interaction are important radiation sources for applications to ultrafast spectroscopy, time-resolved nanoscopy and photonuclear excitations. Here, we present the developments of x-ray/gamma-ray sources from x-ray lasers, betatron radiation and Compton backscattering. In addition, we report the enhancement of the resolution of x-ray coherent diffraction imaging realized by introducing sharp phase gradient in samples illuminated with an x-ray laser at 13 nm.*

Short-pulse x-ray sources have become indispensable diagnostic tools for new material development, condensed matter physics and bio technology. During the past decade extensive progresses have been accomplished in the field of radiation sources based on laser-plasma interactions - x-ray lasers, betatron x-ray radiation and all-optical Compton gamma-rays. Rapid advancement of high intensity laser technology has prompted the investigation of relativistic laser-plasma interactions. At CoReLS two PW Ti:Sapphire laser beamlines with peak powers of 1.0 PW and 1.5 PW were developed and successfully applied to generate stable multi-GeV electron beams. Recently we observed MeV betatron gamma-ray beams in the laser wakefield electron acceleration with the PW laser. We plan to carry out the Compton backscattering to generate MeV gamma-rays from the interaction of a GeV electron beam and another PW laser beam. Here, we present the recent progress in the development of radiation sources based on laser particle acceleration and the plan for developing Compton gamma-ray sources driven by the PW lasers.

The plasma-based soft x-ray laser is one of useful x-ray sources having a large number of coherent soft x-ray photons sufficient for a single shot probe to observe non-repetitive and irreversible phenomena. We developed a Ni-like Ag x-ray laser pumped by a single-profiled pumping pulse in the GRIP scheme and successfully applied it to coherent x-ray diffraction imaging. We developed a method to enhance the spatial resolution of the coherent diffraction imaging by introducing steep phase variation in a sample. From the diffraction signal of the sample with steep phase variation, the sample image was successfully reconstructed with a resolution of 22 nm, close to the diffraction limited resolution. In this presentation, we also report the progress of coherent x-ray imaging obtained with soft x-ray lasers.