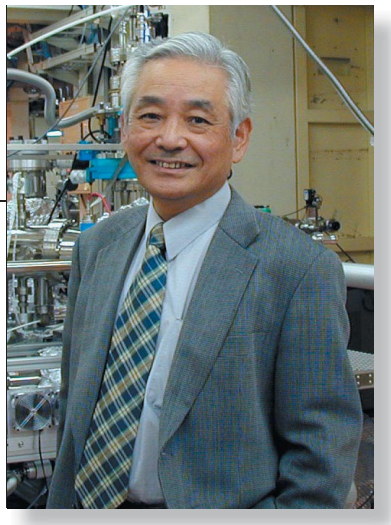
Introduction



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Fiscal 2004 (April, 2004 – March, 2005) was the 22nd year after the first observation of synchrotron radiation at the Photon Factory. It was also a productive and exciting year with a number of new developments and scientific outputs in a variety of research areas.

The most notable event was the start up of the straight section upgrade project of the 2.5-GeV ring. During the last several years, we have been preparing a major upgrade of the 2.5-GeV ring to increase the number of straight sections for insertion devices from seven to thirteen. We were very pleased that we could actually start this straight section upgrade on March 1, 2005, with a seven-month shutdown of the ring scheduled from March to September 2005. As described in 2-2 of the "Accelerator" section, the old quadrupole magnets and vacuum ducts were removed and installation of new ring components were started. This upgrade is a very important step toward the coming five to ten years of the Photon Factory. With an emittance of 36 nmrad, an initial current of 450 mA, and 13 straight sections available for insertion devices, we could say that the Photon Factory 2.5-GeV ring is not a second generation ring anymore. Furthermore, the emittance of the 2.5-GeV ring can be reduced to 27 nmrad, after appropriate machine studies. To make best use of the newly created straight sections, a short period in-vacuum undulator beamline is now under construction for BL-17 (1-2 of the "Experimental Facilities" section). Commissioning of the upgraded 2.5-GeV ring will be started in September 2005 and the commissioning of the in-vacuum undulator beamline and users experiments on other beamlines will begin in October 2005. It is also worth mentioning that several kinds of ring components such as power supplies for the magnets, vacuum ducts, beam position monitors and control systems of magnets, vacuum and RF systems are also being renewed on this occasion, aiming to ensure the reliable operation of the ring for the coming years, even after the 23 years long operation. In addition, to further improve the performance of the 2.5-GeV ring, preparations are being made for the "top-up" injection of the ring (2-3 of "Accelerator" section). Tests will take place in 2005.

In addition to the construction of the in-vacuum undulator beamline, reconstruction of old beamlines and construction of new beamlines have been continued steadily. Re-construction and commissioning of BL-28 for the dedicated use for Angle-resolved photoelectron spectroscopy were completed as described in 1-3 of "Experimental Facilities". A preliminary test showed that the quality of the data, as well as the data collection time for a photoelectron spectrum, was comparable to those of typical experimental stations at third generation rings. We have already started designing another in-vacuum undulator X-ray beamline at BL-3 of the 2.5-GeV ring, and also started discussions on the reconstruction of BL-16 as a dedicated polarization controllable soft X-ray beamline. Most of the beamline components for a new X-ray undulator beamline at NW14 (1-5 of "Experimental Facilities") of the 6.5-GeV ring were manufactured in FY 2004. We plan to install an in-vacuum undualtor and beamline components in the summer of 2005, and this beamline will be commissioned in October, 2005 as the fifth insertion device beamline of the 6.5-GeV ring. A hundred picosecond time resolved diffraction/scattering studies will be carried out with this new beamline to investigate rapid structural changes in photo-induced phase transition of materials. In addition, a new hard X-ray XAFS and an Anomalous X-ray Scattering beamline is now being prepared on the 6.5-GeV ring (1-4 of "Experimental Facilities").

Available user beamtime recorded 98% of scheduled beamtime, both for the 2.5 and 6.5 GeV rings. Such stable and reliable operation contributed very much to vitalize users' experimental programs. We had 721 active experimental proposals and 2,894 registered users, exceeding those numbers in previous years. The number of published papers in calendar 2004 reached 511.

Some of the many highlights of such active users' research programs are summarized in the "Highlight" section. Atomic structures and electronic properties of a number of nano-materials and nano-structures were

investigated. Among those nano-materials were an ice nanotube enclosed in a carbon nanotube (5-2), nanotubes of self-assembled molecules (6-1), hydrogen containing carbon fullerenes (6-2), endohedral metallofullerens (5-4), and antiferromagnetic domains of NiO as imaged by Photolelectron Emission Microscopy (4-3). It should be noted that the hydrogen molecule in the carbon cage of fullerene was clearly detected by the X-ray diffraction technique, despite the common belief that X-rays are not powerful in observing such a light element like hydrogen. A depth resolved magnetization study of Fe/Ni thin layers (4-1) shows the unique strength of the synchrotron technique as a non-destructive tool over other techniques in studying depth dependent properties of materials. Biological science continues its rapid growth as a large and important research area in which synchrotron radiation can play an important role. The Photon Factory protein crystallography beamlines attracted many researchers in this field as described in chapter 8 in the "Highlight" section. Environmental science is also an important field in synchrotron science and a good example is shown in a study of the behavior of arsenic in paddy fields (2-4). Small angle scattering is one of the techniques for which the Photon Factory has many proposals and users. Two examples given in (2-2) and (2-3) show how useful this technique is in obtaining structural information on liquid phase mixtures. We are confident that the Photon Factory has very reliable, user-friendly and productive XAFS stations although they are on bending magnet beamlines. Some examples are found in 2-1, 2-4, 3-2, 3-3, 3-4, 5-3, 8-11, 9-1, 10-1 of "Highlight" section. Particularly interesting is the study of the rewritable optical recording medium (10-1) in which the mechanism of writing and erasing was elucidated at the atomic level.

Although the upgrade program of the 2.5-GeV ring is now on track and the operation of the 6.5-GeV ring is going smoothly, we need to further establish a vision for the coming two to three decades. We believe that the Photon Factory should remain a national facility which can support a wide range of users as well as create and offer new opportunities for cutting-edge sciences by developing the most advanced facilities and techniques. We have recently renewed the administrative scheme and procedures to discuss possibilities of constructing the next generation light source at the Photon Factory and a new committee is going to be organized. This committee will aim at submitting recommendation about the future direction of the Photon Factory to the director of the Institute of Materials Structure Science in 2005. We would appreciate any input about the present status and the future of the Photon Factory from readers of this activity report, regardless of whether you are users of the Photon Factory or not.

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