2 Newly Develped Experimental Systems

2-1 An Energy-Tunable X-Ray Microbeam Irradiation System for Radiobiology

An X-ray microbeam irradiation system for monochromatic X-rays using synchrotron radiation (SR) as a light source has already been developed at the Photon Factory[1]. The energy of the X-rays is limited to 5.35 keV, since the beam is deflected vertically upwards using Si(311) diffraction in order to irradiate samples from below. Presently, the microbeam is cut out using a slit system, providing a square profiled beam of minimum dimension 5 μm. The dose rate is about 40 R/s, which corresponds to about 10^4 photons/s/100μm^2. Using this system, various scientific studies are underway, including studies on bystander effects - radiobiological responses observed in non-irradiated cells which neighbor the irradiated cells. This phenomenon is known to play an important role in the low dose range.

One of the advantages of using a SR light source is that we can select the energy of the monochromatic X-rays, enabling us to study the biological effects of inner-shell ionization followed by Auger effects. These Auger effects lead to the emission of low energy electrons around the photo-absorbing atom, producing complex and severe damage around the site. The radiation biology group at the Photon Factory has reported many studies on biological effects induced by inner-shell ionization of atoms either present in living cells or artificially incorporated into the cells. These studies are important not only from the viewpoint of applications to photon-activation cancer therapy, but also from the viewpoint of the induction of intracellular and intercellular signaling processes leading to cell death of irradiated cells and bystander cells in the low dose range. In order to study the induction of repair or other signaling processes which determine radiobiological responses in the low dose region from the energetic viewpoint, we have constructed an energy-tunable X-ray microbeam irradiation system at BL-27B, using which we can irradiate samples with monochromatic X-rays with energies corresponding to the inner-shell absorption edges of variou elements. Since the horizontal beam as emitted from the electron storage ring must be used, several difficulties had to be overcome, such as the vertical positioning of the sample chamber containing wet cells.

The developed system is shown in Fig. 1. The microbeam slit system, motorized precision stage and epi-fluorescence microscope with cooled-CCD are aligned horizontally to provide a shared center axis. The microscope is aligned to the microbeam using an X-Y stage. For easier alignment, the housing for a mercury lamp is separated from the microscope, and the excitation light from the lamp was introduced to the microscope through a fiber light guide. A commercially available sample dish was employed, developed for use with a confocal laser microscope and having a thin glass bottom. Cells attached to the bottom of the dish are kept humid by covering them with a thin polyimido film after the medium is suctioned out just before irradiation. The physiological condition of cells following treatment in a simulated irradiation process was found to be good enough to obtain reliable and reproducible results. Several studies using the new system have already begun, and preliminary results will be reported soon.

Reference

[1] K. Kobayashi, N. Usami, H. Maezawa, T. Hayashi, K. Hieda and K. Takakura *J. Biomed. Nanotech.*, **2** (2006) 116.

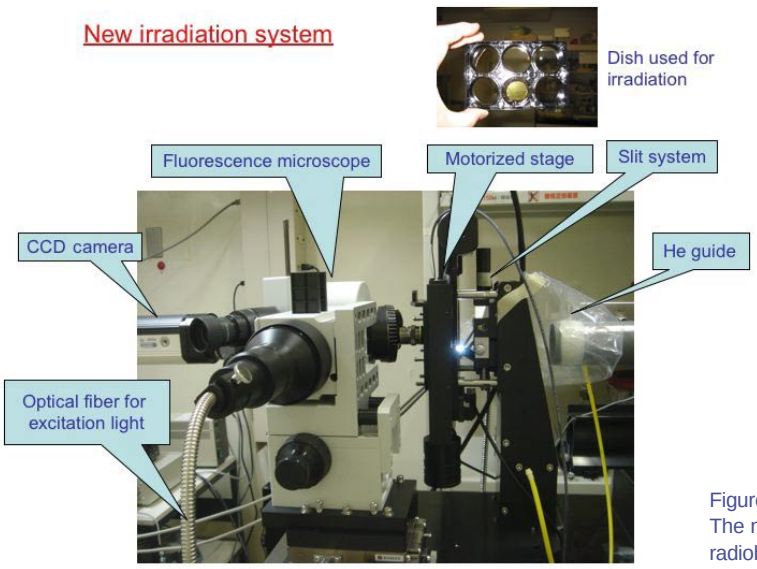

Figure 1
The newly developed X-ray microbeam irradiation system for radiobiology.