Development of 3D micron-CT for living cells

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Abstract

In Particle Induced X-ray Emission (PIXE), the production cross sections of characteristic X-rays are very large in comparison to those of continuous X-rays, which when integrated over the detector resolution are typically 3 orders of magnitude smaller. This feature is quite different from the case of electron bombardment, where the electron bremsstrahlung contributes predominantly to the X-ray spectrum. Due to this inherent advantage, X-rays from a pure metal target bombarded with micro-beams can be considered to constitute a monochromatic X-ray source.

We use this feature in an X-ray CT, which then provides the 3 dimensional structure of a small object with a resolving power of micron size. On the basis of this idea, we develop 3D imaging consisting of a micro-beam system and an X-ray CCD camera. A biological sample is placed in a tube with inside diameter 1000μm and wall thickness 25μm. This tube is rotated by a stepping motor and 2D transmission images of the sample are taken with characteristic K-X-rays produced from a metal target bombarded by 3MeV proton micro-beams. 3D images are reconstructed from these 2D projection images by using an iteration method. We applied our system to investigate an in-vivo sample, in this case being a very small ant. The ant was anaesthetized with chloroform and exposed to characteristic X-rays of Ti. The 3D image of the ant was obtained with a spatial resolution of 4μm. In the usual X-ray CT, X-rays of ~60keV are used and the images reflecting the density of object are obtained. In our case, due to absorption edge and the strong dependence on atomic number of photo ionization cross sections, we obtain images emphasizing the contribution from heavier element. The distribution of K in the gnathic glandula could be clearly imaged.

It is expected that our 3D imaging system could provide cross sectional images of in-vivo samples with high spatial resolution and may thus be applied to a wide range of researches in biology and medicine.

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