Development of a Photon-Counting Dual-Energy Monochromatic X-Ray CT

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Monochromatic x-ray CT has several advantages over conventional CT, which utilizes bremsstrahlung white x-rays from an x-ray tube. A CT Image obtained from a monochromatic x-ray CT shows the distribution of linear attenuation coefficients. By using several different photon energies, we can obtain electron densities, which are quite important for radiotherapy treatment planning.

We have developed a dual-energy monochromatic x-ray CT system aiming at quantitative imaging of large objects. The 256-channel CdTe array detector was used in the photon counting mode. The size of the detector element was 1.98mm(h) x 1.98mm(w) x 0.5mm(t) and the length of total sensitive area was 512mm. Each element has two discriminators (upper discriminator and lower discriminator) and two 16-bit counters (upper counter and lower counter). By changing the discriminator levels with a fixed difference of dV continuously, an incident x-ray spectrum can be obtained.

Several monochromatic x-ray energy spectra were measured using the beamline (BL20B2) at the Biomedical Imaging Center. From the measured spectra, the upper and lower energy limits were obtained for photon energy discrimination.

Cylindrical phantoms of water, alcohol, acetone, paraffin and Lucite were measured at photon energies ranging from 40 to 70 keV. A phantom on a rotating table was projected by a slit beam of 300mm in width onto a CdTe array detector angled to the incident beam at 45°. A total of 360 projections covering 360° were acquired, and CT images were reconstructed.

It has been shown that objects of up to about 300 mm in diameter can be measured with good image quality by this monochromatic x-ray CT system.

Observation of Silicon Front Surface Topographs of a ULSI-Wafer by Synchrotron X-ray Plane Wave

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Nowadays, isolation scheme is used for Si-ULSI device for dimensions as low as 0.2 µm. "Nano-topography" refers to 10-100 nm surface undulations that exist on a lateral millimeter length scale on unpatterned Si wafers measured by optical interferometry from phase shift. On the other hand, present authors have designed and constructed a high-resolution diffraction topography station located in the second hutch in the Biomedical Imaging Centre building at the medium-length (200 m) bending magnet beam line, BL20, at SPring-8 [1, 2]. Using this station, it is possible to take topographs of all over a 300-mm-diameter silicon crystal wafer, because of extremely asymmetric reflections of a 300-mm-wide and monochromatic X-ray beam, available for 9-75 keV energy range, which is monochromatized by Si (311) double-crystal monochromator in the optical hutch.

In this report, we show the topographic, asymmetry grating incident diffraction (GID) geometry around critical angle (0, ~0.07°) using ~22.7 keV energies X-rays, observation results of 8 inches as double-side mechanical-polished silicon wafer including more nanotopography surface features. GID measurement is capable of observing around wafer surface. Figure 1 shows a step-scanned X-ray Topograph multi-exposure, with 5 arcsec step angle, we can observe so-called zebra patterns [3] and circular patterns. The latter pattern is the same as has been observed by the optical measurement. However, no micro-defects are seen in the enlarged picture of Fig. 1. At smaller incident angle (0, ~0.5°) than critical angle clear total reflection topographs were obtained. The authors are grateful to Komatsu Electronic Co. Ltd. for supplying the samples.

References