https://dx.doi.org/10.22161/ijaems.5.1.1 ISSN: 2454-1311

Neutron Imaging and Tomography with Medipix2 and Dental Microroentgenography: An Over View

M. N. Islam[1], H. Akhter[2], R. Rashid[3], M. S. Alam[4], M. Hoq[5], T. Fujiwara[6], S. Kenji[7] and H.Takahashi[8]

[1,2]Electronics Division, Atomic Energy Centre, Bangladesh Atomic Energy Commission, P.O. Box No. 164, Dhaka, Bangladesh.
[3]Material Science Division, Atomic Energy Centre, Bangladesh Atomic Energy Commission, P.O. Box No. 164, Dhaka, Bangladesh.
[4,5]Institute of Electronics, Atomic Energy Research Establishment, Bangladesh Atomic Energy Commission, G.P.O Box 3787, Savar, Dhaka, Bangladesh.
[6,7,8]Department of Nuclear Engineering and Management, University of Tokyo, Japan.
E-mail: nislam_baec@yahoo.com.

***Abstract*— *An over view of Neutron Imaging and Tomography (NIT) with Medipix2 and Dental Micro-roentgenography have been presented in this article. This over view confined to semiconductor detector Medipix2, neutron radiography and tomography and dental microroentgenography. Medipix2 is a pixel-based detector technology employed to measure charge particles, photons (visible through gammas) and neutron. Neutron Beam for this technology are LVR-15 Research Reactor (10^7 n/cm^2 s) and Spallation neutron source (3×10^6n/cm^2 s) .This technology has been verified with photograph and neutronogram of a relay and photograph and tomographic 3D reconstruction of a bullet cartidge, tooth and fishing thread. Comparison of spatial resolution among different imagers also has been presented.*

***Keywords*—*Neutron Imaging and Tomography, Medipix2 and Microroentgenography*.**

I. INTRODUCTION

Neutron Radiography (NR) is based on the application of the universal law of attenuation of radiation passing through matter.

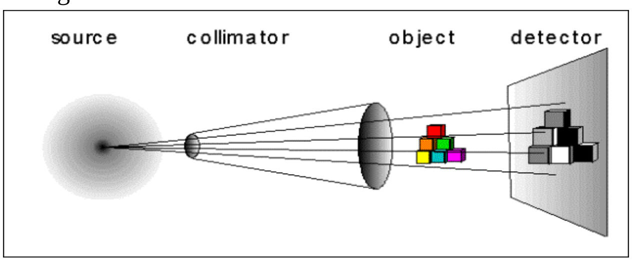


Fig.1: The basic experimental set-up for neutron radiography.

Because different materials have different attenuation behavior. The neutron beam passing through a sample can be interpreted as signal carrying information about the composition and structure of the sample. The basic experimental set-up is given by the following arrangement as shown in fig.1 [1].

Neutrons pass through the sample and strike the scintillation screen. Neutrons ionize the phosphorus in the screen, which cause it to produce flashes of light. The flashes of light are recorded by a camera and converted to numbers in a matrix. Fig.1 describes the configuration of the neutron radiography system. The neutron sources for these experiments are neutron sources LVR-15 Research Reactor (10^7 n/cm^2 s) and Spallation neutron source (3×10^6n/cm^2 s) .And the collimator is a beam forming assembly which determines the geometric properties of the beam and may also contain filters to modify the energy spectrum of the beam or to reduce the content in gamma rays of the beam. The object in the figure above represents the sample that is to be imaged. The selected objects were a relay, a bullet cartidge, tooth and fishing thread. The Medipix2 device with 300μm thick silicon sensor was tested as a neutron detector. The Medipix2 Detector on chip-board (left) is attached to the new USB readout (right) which connects to PC via USB as shown in fig.2 [2, 3].

II. METHODOLOGY

2.1: Compact portable set up with USB interface

The Medipix2 Detector on chip-board (left) is attached to the new USB readout (right) which connects to PC via USB. USB provides both communication and power

https://dx.doi.org/10.22161/ijaems.5.1.1 ISSN: 2454-1311

supply lines. A significant reduction in interface electronics dimensions is achieved and no external power supply.

Fig.2: Compact portable set up with USB interface.

2.2: Semiconductor Detector Medipix2

The state-of-art semiconductor hybrid pixel detector Medipix2 consists of converter, detector chip, bump-bonding and readout chip.

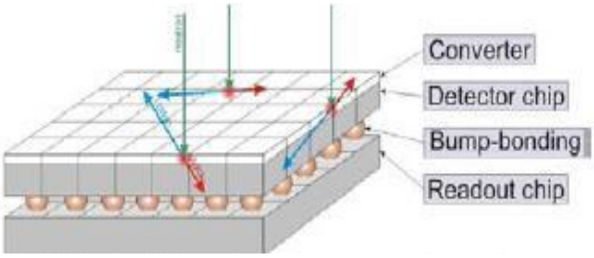


Fig.3: Coated ^{6}LiF neutron converter deposited on the sensor surface. Heavy charged particles are detected within few pixels.

Various converter materials were investigated such as ^{6}LiF powder, Amorphous ^{10}B, Cadmium foil and Gadolinium. ^{6}LiF produces exclusively heavy charge particles and no gamma rays. Compact USB Readout Chip comprises of Preamplifier, Discriminator, Digital Counter,DAQ PCI Card, User friendly software and Sensor Bias Voltage (5 – 100V).

2.3: Neutron Radiography

During neutron radiography image of a relay taken with metal cover in place as shown in fig.4.

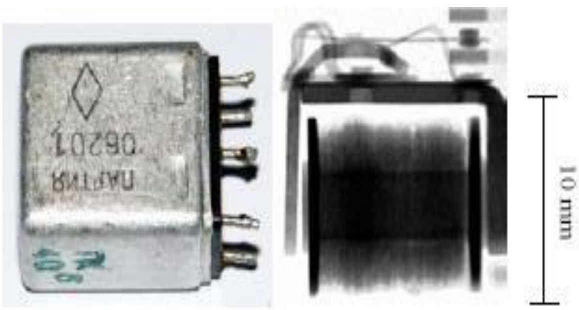


Fig.4: Photograph and Neutronogram of a relay.

2.4: Neutron Tomography

During neutron tomography blank cartridge (inner powder filling) and tooth have been used as object. 100 projections/150s taken for each object as shown in fig.5 and fig.6 .The Filtered Back Projection algorithm for reconstruction.

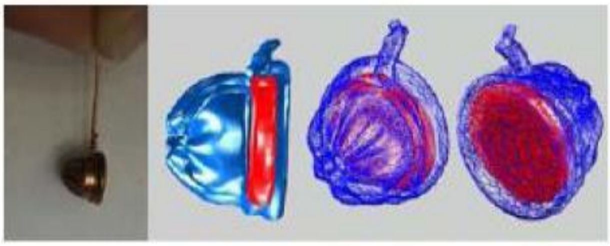


Fig.5: Photograph and tomographic 3D reconstructions of blank cartridge (inner powder filling is shown in red).

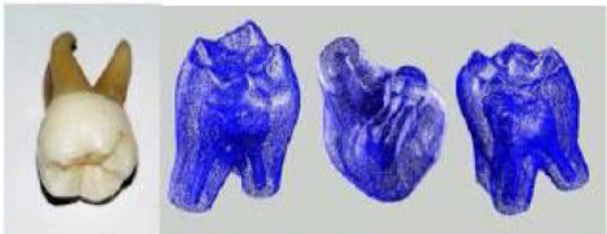


Fig.6: Photograph and tomographic 3D reconstructions of tooth.

2.5: Dental Microroentgenography

Based on Medipix position sensitive detector fully electronic, high efficiency (low dose) and high spatial resolution portable digital dental imaging device. To observe the bone-to-implant interface and surrounding bone tissue of orders tens of microns (X-ray Source L8601-01). Preliminary tests were carried out on Phantoms of dental implants coated by a thin wax layer (simulating bone-to-implant tissue interface) embedded in plaster (simulating bone). A wax layer 40 micrometer thick was determined for the selected position.

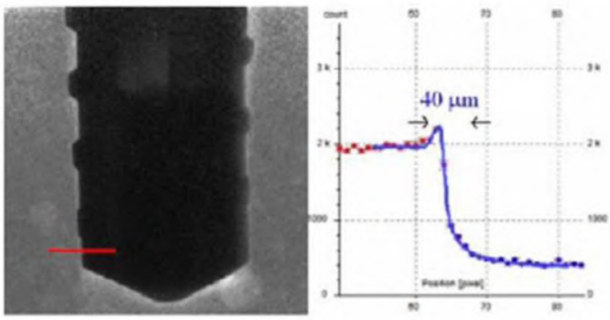


Fig.7: Medipix2 transmission X-ray image (left) and transmission curve and fit (right) of implant phantom. Image acquired in 150s (dose ~ 4mGy) with 3x magnification.

https://dx.doi.org/10.22161/ijaems.5.1.1 ISSN: 2454-1311

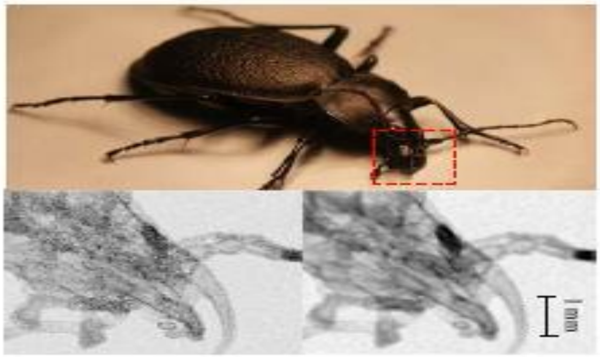


Fig.8: Photograph (above) and X-ray transmission radiograms (below) of a ground beetle with two methods of flat-field correction: standard (left) and newly developed calibration method (right).

2.6: Results and Discussion

High spatial resolution, single quanta counting digital imaging device for X-ray and Neutron imaging USB Readout adds portability and ease of use. Therefore, isotropic illumination by diffuse source as shown in fig.9. Isotropic and diffuse neutron reactor source significance for objects rich in H and light elements, Increase the detection efficiency and transmission imaging techniques.

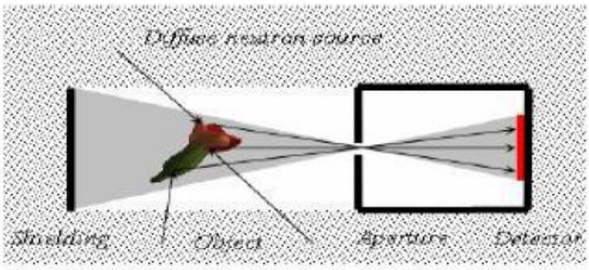


Fig.9: Neutron radiography with isotropic illumination in a diffuse field.

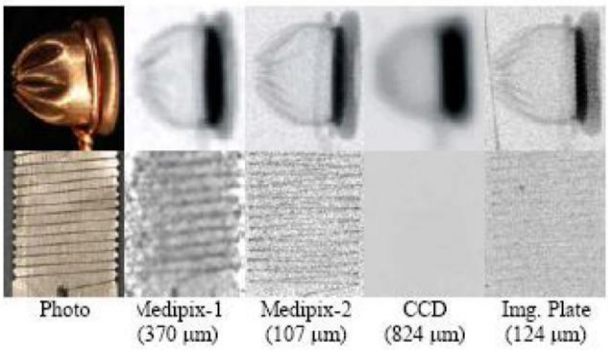
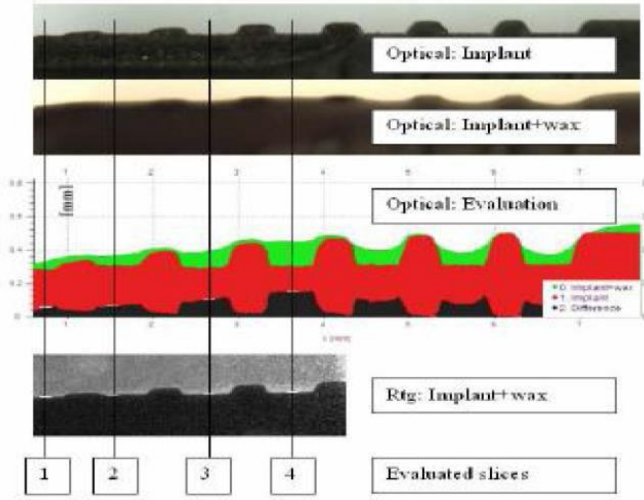


Fig.10: Photograph and neutronographs of bullet cartridge (top) and finishing thread with 100 μm in diameter (bottom) taken by different imagers. Spatial resolution (FWHM of LSF) is included.

Comparison of spatial resolution for bullet cartridge (top) and finishing thread with 100 μm in diameter (bottom) among different imaging devices such as medipix-1 (370 μm), medipix-2 (107 μm), CCD (824 μm) and image plate (124 μm) have been shown in fig.10.



Slice	Rtg Measurement [μm]	Error Estimation [μm]	Optical Measurement [μm]	Difference [μm]
1	40,1	2,9	40,0	0,1
2	75,4	10,9	65,2	10,2
3	106,2	9,8	96,9	9,3
4	150,8	8,6	148,0	2,8

Fig.11: Interface wax thickness from X-ray transmission measurements evaluated along 4 slices directions. Comparison with optical method (top) is included.

Comparison and Verification of Results with Optical Measurements have been shown in fig.11. Interface wax thickness from X-ray Transmission Measurements evaluated along 4 slice directions. It has been observed that differences between Rtg measurement and optical measurement in 4 slices are 0.1 μm, 10.2 μm, 9.3 μm and 2.8 μm respectively. The error estimations in Rtg measurement for the same slices are 2.9 μm, 10.9 μm, 9.8 μm and 8.6 μm respectively.

III. CONCLUSION

An elaborate study about the Neutron Imaging and Tomography (NIT) with pixel-based detector Medipix2 of high spatial resolution, single quanta counting digital imaging device for X-ray and Neutron Imaging have been presented in this article. USB Readout adds portability, ease of use, significant reduction in interface electronics and no external power supply. Moreover, dental roentgenography is a high resolution microimaging device. Isotropic illumination by diffuse neutron source is also being investigated.

https://dx.doi.org/10.22161/ijaems.5.1.1 *ISSN: 2454-1311*

ACKNOWLEDGEMENTS

Authors wish to express deep gratitude to Nuclear Safety Research Association (NSRA), Japan for selecting University of Tokyo (UT) as the host institution to conduct a research theme "Practice in Radiation Measurements and Instrumentation".

REFERENCES

[1] https://nuclear.engr.utexas.edu/index.php/netl/services/neutron-radiography,Available Online in 2017.

[2] https://medipix.web.cern.ch/medipix/pages/medipix2.php, Available Online in 2017.

[3] J. Jakubek, C. Granja, T. Holy, E. Lahmann, V. Linhart, S. Pospisil, V. Rypar, J. Uher, J. Vacik, D. Vavrik, Z. Vykydal and M. Cevallos, Neutron Imaging and Tomography with Medipix2 and Dental Micro-roentgenography, Nuclear Instruments and Methods in Physics Research: Section A, Vol.569, Issue 2. Dec 20, 2006.