

Dosimetry of the MicroLeman Collimated X-ray Setup for Cell Irradiation*

A. Tütüncü¹, R. Khan^{1,2}, M. Durante^{1,2}, G. Taucher-Scholz^{1,2} and B. Jakob¹

¹GSI, Darmstadt, Germany; ²TUD, Darmstadt, Germany

Introduction

Collimated x-rays may be used for subnuclear exposure of cells to ionizing irradiation to compare the biological response to that induced by charged particles. Collimation was done using wafer stacks of silicon or GaAs with etched grooves in the order of some μm using the MicroLeman setup (Fig.1 left). To determine appropriate irradiation conditions for the evaluation of biological damage, we started to establish a spatially resolving dosimetry utilizing different radiochromic films and micro-scopic readout.

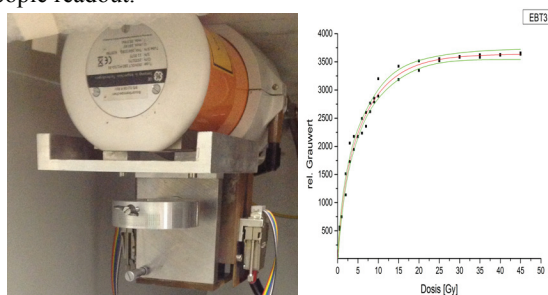


Figure 1: Left: X-ray tube G&E 160M1 equipped with the MicroLeman irradiator device. Right: Dose response curve of the EBT3 film for 35kV irradiation.

Method

Irradiation was done using a G&E ISOVOLT 160 M1 / 10-55 x-ray tube. Omitting the collimators, we recorded calibration curves at different tube voltages (20 to 35 kV) using Gafchromic EBT3 and MD-V2-55 radiochromic films and an ionization chamber as reference. Absorption changes of the films were measured either in 48-bit RGB modus of a Canon LIDE210 flatbed scanner (Fig. 2 left) or using the transmission channel in a Leica confocal microscope (Fig. 2 right and Fig 3 left).

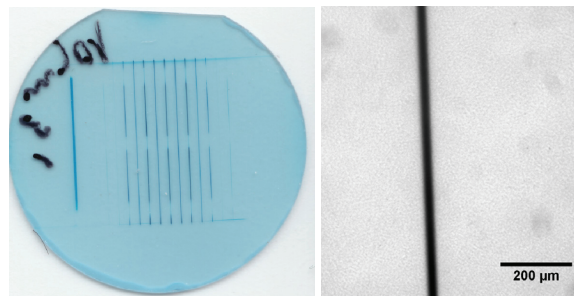


Figure 2: Left: EBT film irradiated for 3 min using the 10 μm GaAs collimator. Film was scanned with the scanner (left) or with higher resolution under the microscope (right).

Results

Recorded grey or colour values of the radiochromic films were plotted against the applied dose and fitted by exponential functions (Fig. 1). The EBT3 films showed a higher sensitivity compared to the MD-V2-55 (not shown), However a saturation behaviour above 12 Gy in EBT3 limits the usable range, whereas the MD V2-55 could be used up to doses of >100 Gy. The obtained calibration curves for different radiation energies (20-35 kV) allowed the assignment of the corresponding local dose using the different collimators (1 to 10 μm slits). Dose was colour coded for better visualization (Fig. 3).

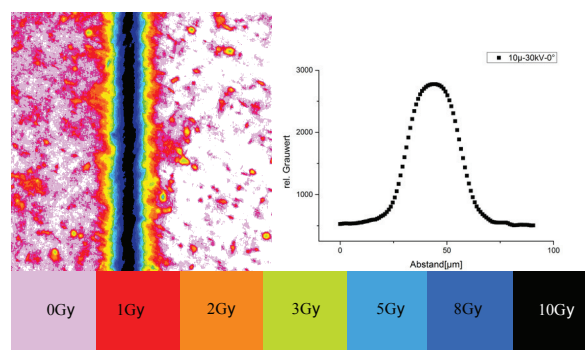


Figure 3: Left: High resolution microscopic image of the EBT film shown above. Colours indicate the applied dose. Central dose exceeds 10 Gy whereas the dose in the shielded areas was below 1 Gy. The profile (right) showed a fwhm of around 30 μm for the 10 μm collimator.

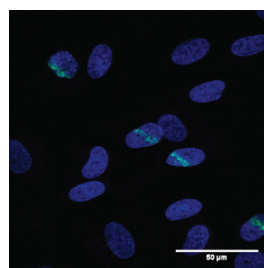


Figure 4: Irradiated AG1522 cells using the 1 μm collimator stained against γ -H2AX (green) and DNA (blue)

First cell irradiation experiments were done using the Microleman setup. Fig.4 exemplarily shows human fibroblasts irradiated with the 1 μm GaAs collimator for 5 min at 35 kV. A green band of γ -H2AX indicates the presence of double-strand breaks (DSBs) along the slit.

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