Radiosensitization by Au-nanofilm at micrometer level using confocal Raman spectroscopy

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In the last few decades, in the radiation dosimetry field Monte Carlo simulations have been widely used to estimate the radio-enhancement by metal nanoparticles at the micrometer level. However, such studies suffer from a lack of experimental verification, especially radio-enhancement measurements at a few μm distance from the metal nanoparticles. Monte Carlo Simulations have shown that dose deposited due to LEE's is significantly higher within a few micrometers directly from metal nanoparticles when irradiated by low energy x-rays. This study demonstrates the exceptional capacity of confocal Raman spectroscopy (CRS) to measure radiation dose deposition at micrometer scales as no other experimental device has been able to do so far. Raman spectra of radiochromic films (RCF) were measured by positioning the post-irradiated RCF perpendicular to the CRS monochromatic beam and reading a depth profile of the film along the lateral axis. The Raman peak corresponding to the C≡C peak was obtained from a region of interest of 100 × 5 μm^2. To investigate the radiosensitization by gold nano-film (GNF), two sets of RCF, one attached to a 100 nm-thick GNF and the other without GNF were irradiated at 0.5 Gy by 50 and 120 kVp X-rays. The spatial resolution of the CRS on the RCF was quantified by the modulation transfer function method (MTF). Thus, in the spatial resolution determined by MTF, the doses deposited on the films were evaluated. The dose enhancement factor (DEF) was obtained in the measurable micro-size by comparing doses deposited on the RCFs with and without GNF. To verify the experimental results, Monte Carlo simulations following the experimental set up were performed using Geant4. In addition, analytical calculations for the radiosensitization by GNF were carried out. The confocal Raman spectroscopy on the RCF achieved a spatial resolution of ~6 μm. An experimental DEF within the first 6 μm depth from the surface of RCF was found to be 17.9 for 50 kVp and 14.7 for 120 kVp. The DEF for the same depth obtained by MC and analytical calculations was 13.53 and 9.75 for 50 kVp, and 10.63 and 6.67 for 120 kVp, respectively.

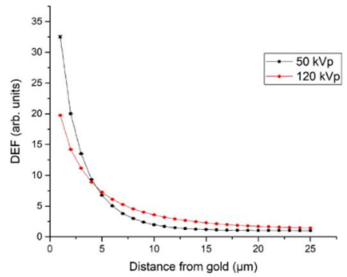

Fig. 1. Dose enhancement factor (DEF) on every 1 μm of the active layer of the EBT-XD obtained from the Monte Carlo simulations.

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