X-rays and field-emission gun: an intrinsic quasi-monochromatic X-ray source

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Carbon nanopearl field-emission (FE) cathode[1-2] was used as a high brightness cold electron source in a conventional reflection x-ray set up, with a vacuum in the range of 10^{-6} to 10^{-7} Torr. A quasi-monochromatic soft x-ray emission was obtained by privileging electron-excited characteristic L-shell radiations. The values of the x-ray monochromaticity were between 55 and 75 %.

The FE gun was composed of a 7-tip carbon nanopearl cathode arranged in a circular array, an extracting electrode, a grid and a focus electrode. Moreover, they were independently powered and the FE current of each tip can reach 70 to 100 µA. The lifetime of the carbon nanopearl cathodes was suitable for x-ray application. For example, a cathode array was still active for a cumulative working time of more than 150 hours.
The production of x-ray L-shell characteristic peaks originated from direct and indirect processes[3], the yield I_L is given by $I_L \propto (U_L\text{-}1)^{1.67}$, where U_L is the ratio of the e-impact energy E_e to the L-shell ionization energy. Fig. 1 showed an example of the quasi-monochromatic x-ray spectra with, in the inset, the variations of the intensity of the L-peak and its monochromaticity versus E_e.

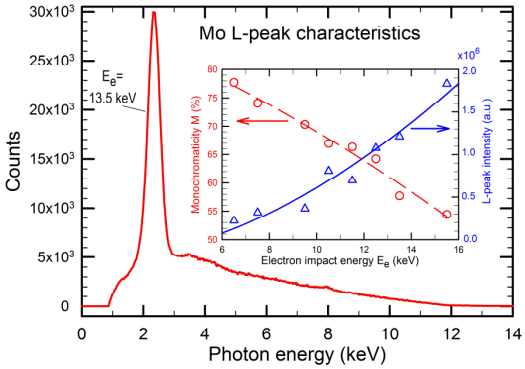

Fig. 1: Quasi-monochromatic FE X-ray spectrum.

The future development of the direct quasi-monochromatic FE x-ray sources should take advantage of the two main FE e-beam characteristics- easy e-beam focus for developing point x-ray source and high frequency switching in a simple configuration – in concomitance with ambient working temperature, high x-ray yield and extreme miniaturization. This suggests applications for high resolution phase contrast imaging, in microradiology or microtomography for example, as well as novel developments in coherent soft x-ray radiotherapy and nanolithography.

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