Investigation of an emission current regulation circuit in the frequency domain

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ABSTRACT

In x-ray sources [1], stable and low noise field emission electron sources are required. If metal- or metal-like emitters are used, the necessary field emission stability cannot be achieved without using external regulation circuits. Instable surface states and adsorbates caused by ion bombardment especially in rough vacuum results in high current fluctuations. A regulation circuit was developed and successfully implemented in our measurement setup [2]. To investigate the frequency behaviour of this regulation circuit, an experiment with a p-type Si field emission array illuminated by a light source was carried out. The use of p-type Si emitters basically leads to a stable and low-noise field emission in the saturation regime. This is caused by the depletion of charge carriers, so that fluctuations of $\approx 2\%$ can be expected [3]. However, the current is lower compared to metal-like emitters with the same geometry.
For this measurements we used a p-type Si field emission array consisting of 10x10 high aspect ratio tips [3] at 10^{-9}mbar. The I-V characterization without illumination yielded the expected behaviour with a saturation of the emission current for voltages higher than $\approx 500V$ (Fig. 1). As expected, the illumination of the sample with a light source shifts the saturation region towards higher current values and the emission behaviour is more similar to a metal-like emitter. Controlling the light source by a noise generator with adjustable bandwidth allows us to simulate a metal-like emitter with variable noise behaviour to evaluate the bandwidth performance of the regulation circuit. Therefore, we measured the current in the frequency domain by extending our measure-setup by an oscilloscope with integrated FFT to record frequency spectra. The frequency spectra without and with noisy illumination of the unregulated electron source are shown in Fig. 2. The peaks at $50Hz$ and its harmonics are caused by the power-line. All results of the performance investigation of the regulation circuit will be presented in detail at the conference.

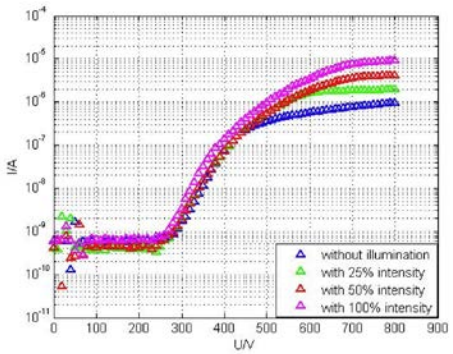

Fig. 1: I-V curves of a p-type Si field emitter array with different illumination intensities.

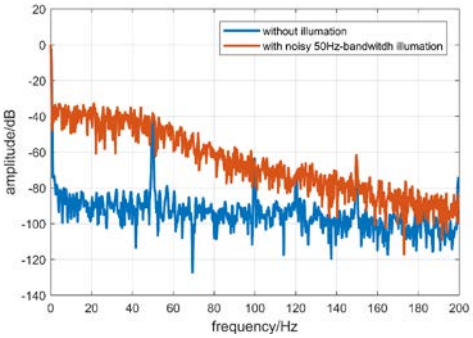

Fig. 2: Frequency spectrum of the emission current in the saturation region at 600V without illumination (blue) and with noisy 50Hz-bandwith illumination (orange). Spectra are normalized to the corresponding current at 0Hz.

References

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