Off-Axis Emission Properties for the Schottky Electron Source

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Most studies of the emission properties, such as energy spread and brightness, of high field, point electron sources have been confined to the axial direction. In this study we investigate the off-axis emission properties of a rotationally symmetric W(100)/ZrO Schottky source[2]. In the case of a high field electron source with a hemispherical apex the emission properties would be expected to vary in a monotonic fashion with the beam angle relative to the axial direction. However, as shown in Fig. 1, the stable end-form of the W(100)/ZrO Schottky source emitter apex consists of a polyhedral shape with a (100) plane normal to the emitter axis and side facets consisting of {112} and {110} planes. Singularities in the electric field can occur at the intersection of these planes which can have a profound effect on two important source parameters - the energy distribution and brightness.

Fig. 2 shows the variation of the total energy spread as a function of emission angle at a constant value of angular current density and a source temperature of 1800 K and emitter radius of ~ 440 nm. As described elsewhere[3] the full width half maximum of the experimentally (FWHM(exp)) measured energy distribution can be separated into the fundamental intrinsic (FWHM(int.)) and Boersch (FWHM(B)) contributions. The electron-electron interactions are the source of the well known Boersch contribution. The Fig. 2 results show that both the intrinsic and Boersch contributions increase with beam angle. A beam angle of 4^o corresponds to an emission from near the edge of the (100) flat shown in Fig. 1. The FWHM(exp.) increases ~ 18 % as the beam angle increases from 0 to 4^o.

From the I(V) data at each angle the local geometric field factor β (i.e. the ratio of the local electric field to applied voltage V) and practical reduced brightness[4] ($B_r = 1.44J/\pi kT$) can be determined as shown in Fig. 3. A rather large (~ 30%) increase in both β and B_r is observed as the beam angle increases from 0 to 4^o.

Other emission parameters that have been measured as a function of beam angle include the angular current density, work function and angular magnification. The method of measurement and significance of these results will be discussed more fully.

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[1] Email: Greg.Schwind@FEI.com

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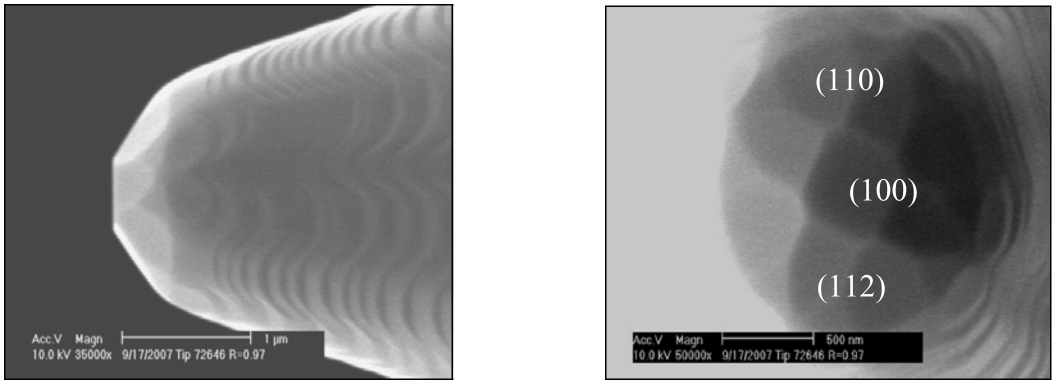

(a) (b)

Fig. 1 Side view (a) and top down view (b) of the W(100)/ZrO Schotty electron source with the different crystal planes labeled.

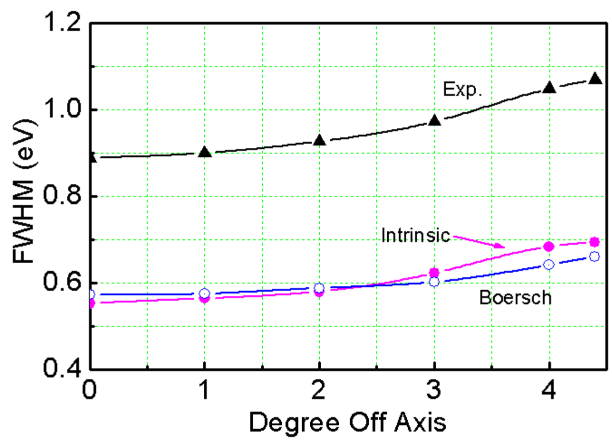

Figure 2. The energy spread FWHM is plotted vs. beam angle for the experimental, intrinsic and Boersch contributions. The angular current density and temperature were held constant at 0.5 mA/sr and 1800 K respectively.

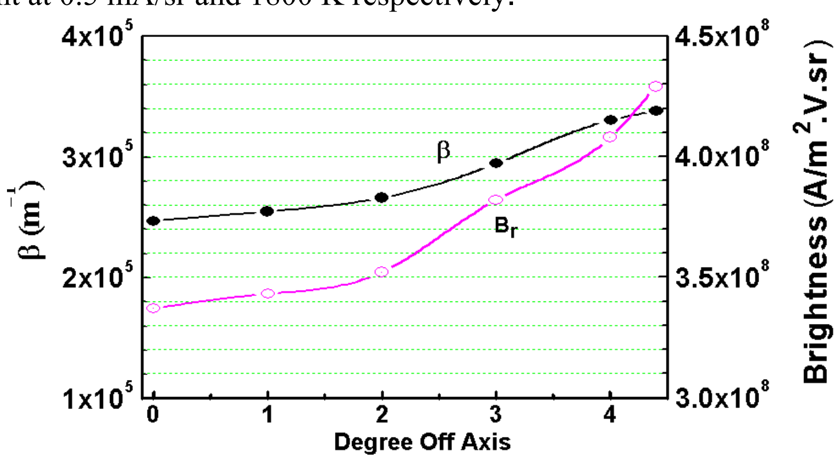

Figure 3. The source reduced brightness B_r and β factor are plotted vs. beam angle. The angular current density and temperature were held constant at 0.5 mA/sr and 1800 K respectively.