Evaluation of LaB_6 nanowire emitter

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LaB_6 nanowire field emitter has been reported about its fabrication and characterization by H. Zhang et al. in NIMS (National Institute for Materials Science) [1]. This emitter has significant characteristics compared to W(310) cold field emitter. It provides quite high brightness ($>1.0\times10^{11}$ A/m^{2}sr/V) and low energy spread(≒0.2eV). Figure 1 indicates an illustration of the emitter. An LaB_6 nanowire (thickness 50-80nm, length 10-20μm) was fixed on the W(Ta) tip. A highly collimated electron beam was generated from the LaB_6 nanowire by applying a low voltage of a few hundred volts after field activation. The beam divergence is about 5°, much narrower than the angle of 70°from the current W(310) emitter.

We investigated the details of emissions characteristics. Figure 2 shows (a) a long-term stability of the electron emission current of the LaB_6 nanowire emitter. For comparison, the stability of the W(310) emitter is indicated in Fig.2(b). The gun chamber pressure was kept at around 1×10^{-8} Pa for both tests. Total emission current is about 45nA at an extract voltage of 310V, and long-term stability is better than that of W(310) emitter. The attenuation rate is 0.8% / hour for LaB_6 emitter and 9% / hour for W(310) emitter. For short-term stability, we examined two methods for obtaining stability of emission current. One is a flushing method and the other is a reverse bias application method. Both methods are beneficial about stability of the emission current. For example, Fig.2(c) indicates the short-term stability of the emission current after reverse bias application. The stability was 0.14/min at that time. This suggests that the emission current can be stabilized by cleaning due to desorption of adsorbed gas molecules from the surface of the LaB_6 nanowire.

On the other hand, we investigated application to TEM. Figure 3 shows the energy spread after measurement by the omega energy filter of JEM-2200FS, JEOL Ltd. We could obtain 0.26eV as FWHM of zero-loss spectrum peak in this figure. We would like to discuss about possibility of application to TEM, such as the relationship between the surface condition of LaB_6 nanowire and the method of stabilizing emission current.

[1] H. Zhang, et al., Nature Nanotech.11 (3), 273-279 (2016).

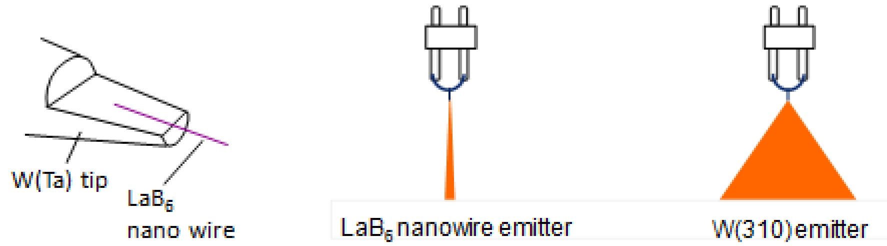

Figure 1. Illustration of LaB_6 nano wire emitter. Schematic diagram of electron emission from this emitter. The beam divergence is about 5° against 70° of W(310) emitter [1] .

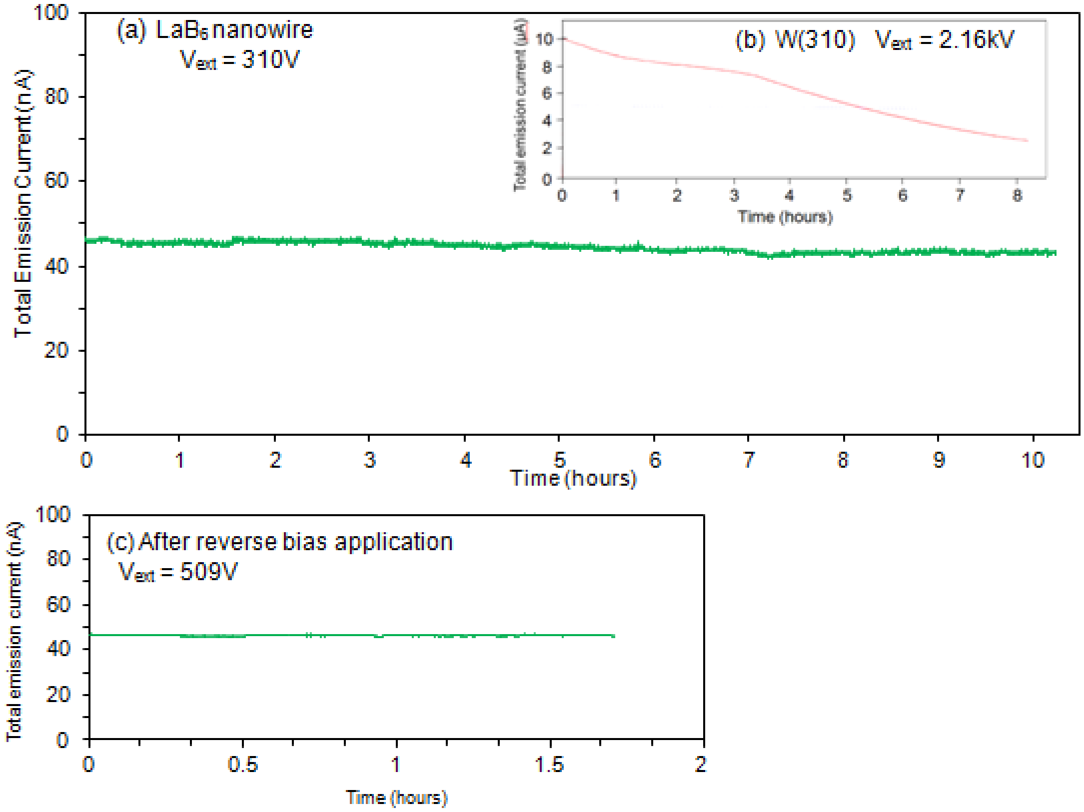

Figure 2. Long-term stability of emission current from (a) LaB_6 nanowire and (b) W(310) emitter. (c) Stability after reverse bias application.

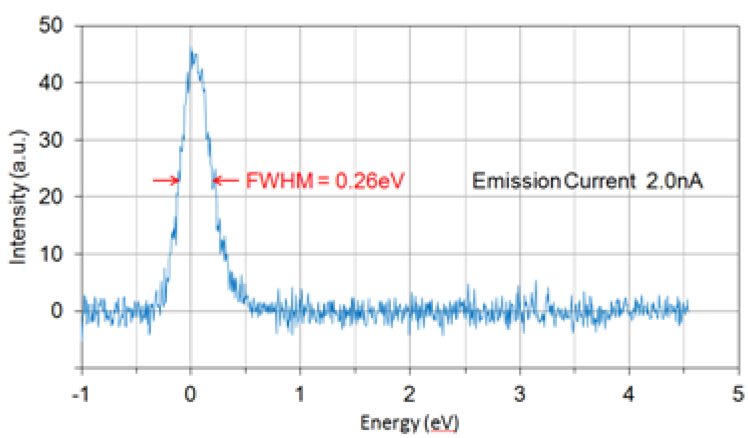

Figure 3. Energy spread obtained by omega energy filter of TEM.