Generation of higher than 1000 A/cm^2 continuous wave electron beam emission from InGaN photocathode

A. Koizumi, D. Sato, H. Shikano, and T. Nishitani
Photo electron Soul Inc., 3-7-4 Toshin-sakura building 10F, Sakae, Naka-ku, Nagoya 460-0008, Japan
a.koizumi@photoelectronsoul.com

The electron beam from semiconductor photocathodes with negative electron affinity (NEA) state can solve the trade-off relation between the beam current and the energy dispersion, which are related to the beam performance such as brightness. The emission current density is one of the most important parameters to obtain high brightness. In this contribution, we investigated the dependence of the electron emission current on the excitation laser power density of the NEA-InGaN photocathode.

The InGaN/GaN photocathode was grown on a double-sided polished (0001) sapphire substrate by metal-organic chemical vapor deposition. The semiconductor surface was cleaned by heating in a test chamber. Then, the InGaN photocathode was activated by alternating deposition of Cs and O_2 to obtain the NEA state surface.[1] The photocathode was excited by irradiating a continuous wave 405 nm laser from the backside of the photocathode. The excitation power density dependence of the emission current density was measured with acceleration voltage of -15 kV. The excitation power density was varied by both the excitation area and the excitation laser power. The diameter of the excitation area was defined as 4σ of the laser profile. The emission current was measured by reading the current monitor of the high-voltage power supply.

Figure 1 shows the excitation power density dependence of the electron emission current density of the NEA-InGaN photocathode. The symbols in Fig. 1 indicate the diameters of the excitation areas of the measurements. The emission current density increases with the excitation laser power density. The maximum emission current density of 1400 A/cm^2 was obtained at the excitation power density of 6.4×10^5 W/cm^2. The quantum efficiency at the maximum emission current density was 0.68%. The slope of the increase in current density with respect to the excitation power density slightly decreases in the region of the excitation power density higher than ~1 W/cm^2. This behavior can be explained by the decrease of the escape probability of the electron from the surface into the vacuum owing to the surface photovoltage (SPV) effect[2]. Although a saturation was reported in NEA-GaAs photocathodes[3], the saturation was not observed under the excitation conditions in the NEA-InGaN photocathode.

---

[1] N. Takahashi, S. Tanaka, M. Ichikawa, Y. Q. Cai, and M. Kamada, J. Phys. Soc. Jpn. **66**, 2798 (1997).
[2] A. Herrera- Gómez, G. Vergara, and W. E. Spicer, J. Appl. Phys. **79**, 7318 (1996).
[3] B. I. Reznikov and A. V. Subashiev, Semicond. **32**, 1006 (1998).

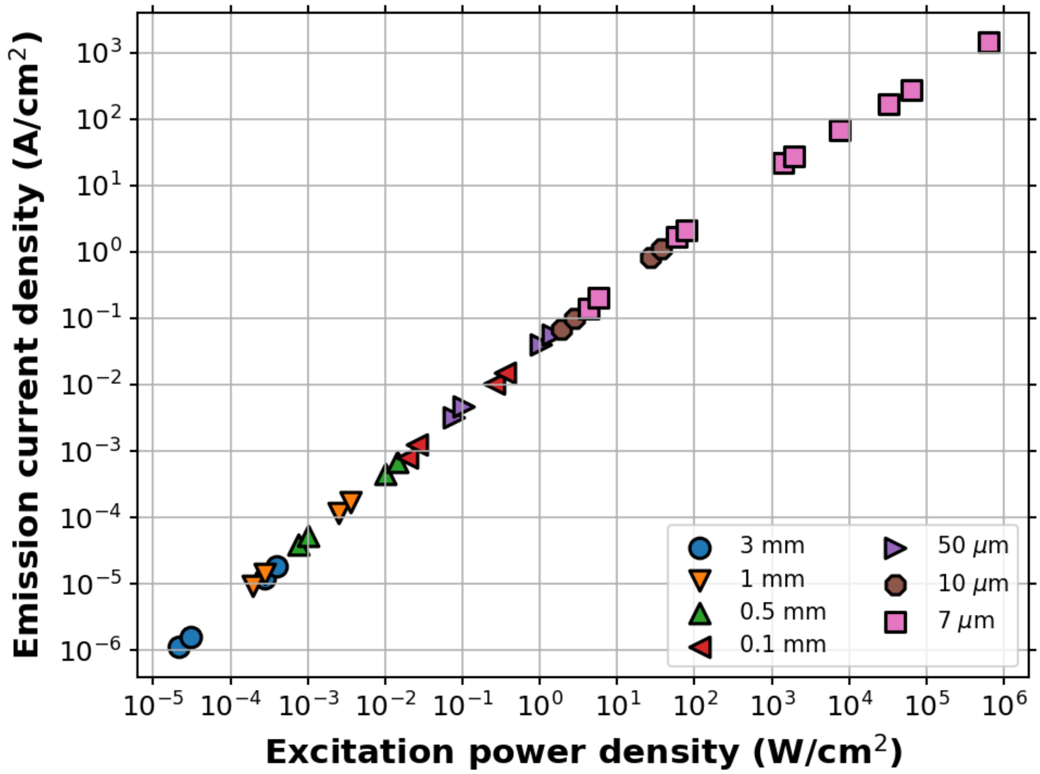

Figure 1: Excitation power density dependence of electron emission current density of the NEA-InGaN photocathode: The emission current density increases with the excitation laser power density. The maximum emission current density of 1400 A/cm^2 was obtained at the excitation power density of 6.4×10^5 W/cm^2.