Pulsed electron beam generation from InGaN photocathode

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Semiconductor photocathodes have characteristics such as a low electron energy dispersion of less than 0.1 eV and a high electron beam current generation more than 5 mA, which realizes high brightness electron beam.[1, 2] In addition, they can generate a short pulse electron beam such as 2.4 ps width.[3] By controlling the photocurrent of the electron beam in a short time, the intensity of electron beam irradiation can be arbitrarily changed in the specific areas during the imaging of scanning electron microscopy. The rise and the fall times of the electron beam current need to be less than 10 ns to control the electron beam dose within a pixel of the image at high speed. In this contribution, we investigated the time response of the pulsed electron beam generated from the InGaN photocathode.

A p-type InGaN with a cesium oxide activated surface was used for the photocathode. The backside of the InGaN photocathode was irradiated with a laser having a wavelength of 405 nm for the photoexcitation. The pulse width and the repetition rate were modulated by a digital delay generator. Temporal profiles of the electron beam currents were measured by an oscilloscope, having a frequency band of 1.5 GHz, connected with a Faraday cup. Temporal profiles of the laser power were measured by a high-speed photodetector inserted into the split irradiation laser path.

Figure 1 shows the temporal profiles of the pulsed laser power and the pulsed electron beam current. The pulse width of the laser was 3.6 ns. The full width at half maximum of the electron beam current was 3.8 ns and the peak current was 780 µA which corresponds to the current density of 2×10^3A/cm^2. The rise and fall times were 1.7 and 2.0 ns, respectively. Therefore, the InGaN photocathode can provide ON/OFF control of the electron beam within 2 ns. Figure 2 shows the temporal profiles of laser power and photocurrent, where the laser irradiation size was changed from 7 µm to 3 mm. The temporal profile of the electron beam current shows a similar curve to that of laser power with an irradiation size of 3 mm. Meanwhile, the temporal profile of the photocurrent shows a decay-like curve with an irradiation size of less than 1 mm. The reason for the photocurrent decay in each pulse will be discussed.

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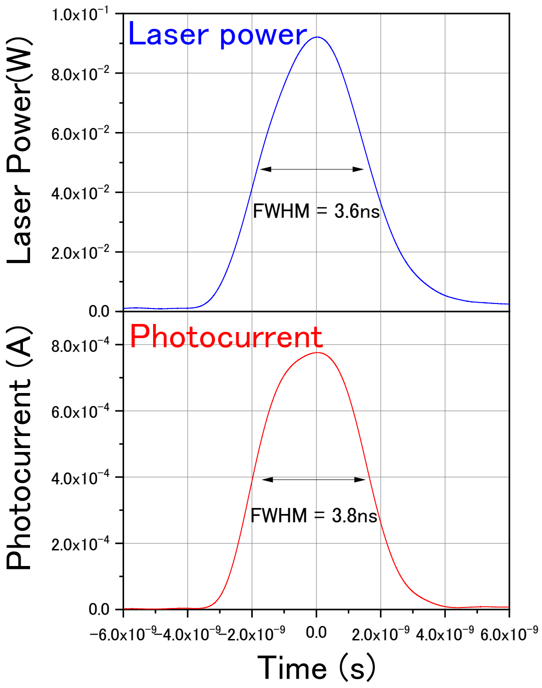

Figure 1: Temporal profiles of laser power and photocurrent from InGaN photocathode. The repetition rate and the laser irradiation diameter were 10 Hz and 7 µm, respectively. The acceleration voltage of the electron beam was −15 kV.

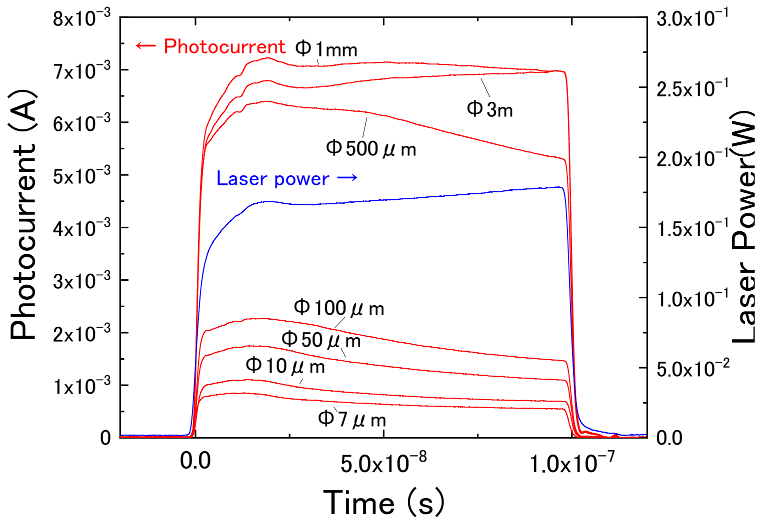

Figure 2: Temporal profiles of laser power and photocurrent with various laser diameters. Pulse width and the repetition rate were 100 ns and 10 Hz, respectively. The acceleration voltage of the electron beam was −15 kV.