Effect of threading dislocation density on electron emission yield in InGaN photocathode

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Semiconductor photocathodes are expected to be used as electron beam source for inspection equipment used in semiconductor manufacturing processes because they have features such as high current, low energy dispersion, short pulses and multiple beams. The electron emission yield of semiconductor photocathodes is affected by the photo-excited electron lifetime in the semiconductor.[1] The electron lifetime is inversely related to the threading dislocation density (TDD).[2] In this study, we fabricated InGaN photocathode on sapphire substrate, patterned sapphire substrate (PSS), and GaN substrate to improve the electron emission yield.

The InGaN/GaN photocathodes were grown on sapphire substrate, PSS, and GaN substrate. The surface of the photocathodes were cleaned by heating under an extremely high vacuum (about 5×10^{-9} Pa) in the evaluation equipment. The negative electron affinity (NEA) surface was activated using the Yo-Yo method, in which Cs and O_2 are alternately supplied to the photocathode surface. The quantum efficiency (QE) was measured under the following conditions: acceleration voltage of -100 V, excitation power density of 1.27 W/cm^2, and wavelength of 405 nm. Full width at half maximum (FWHM) of $(10\bar{1}2)$ GaN X-ray rocking curve (XRC) was measured to evaluate the TDD for the photocathodes grown on the respective substrates.

Figure 1 shows the QE dependence on the FWHM of XRC. In the figure, the QE was increased with decrease the FWHM of XRC. It is known that the FWHM of XRC becomes smaller, the TDD becomes decrease.[3] Therefore, we have succeeded to improve the QE of InGaN photocathode by decrease of the TDD.

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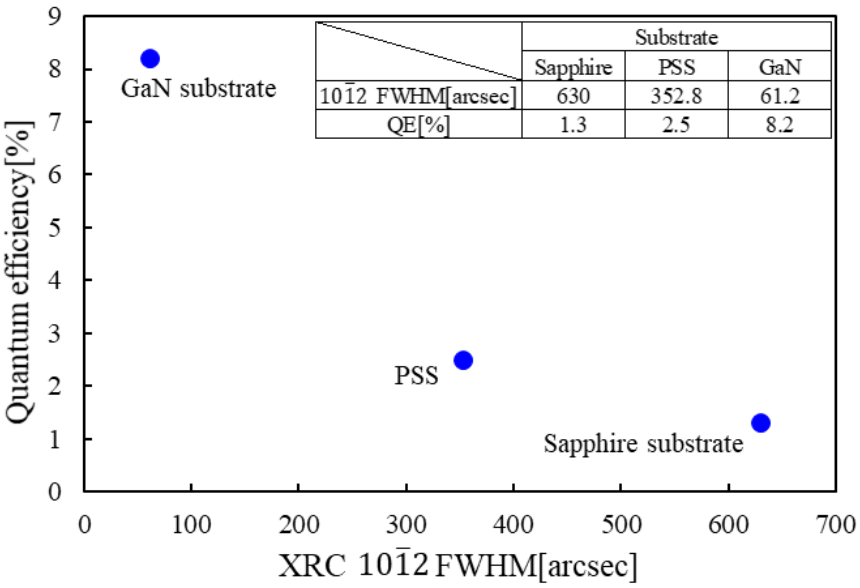

Figure 1: Quantum efficiency of InGaN/GaN photocathodes with a GaN, a patterned sapphire, and a sapphire substrate. The horizontal axis shows the full width at half maximum of the X-ray rocking curve for GaN (10$\bar{1}$2).