New transmission-type photocathode structure based on strain-compensated superlattice

X.G. Jin1, M. Tanioku1, Y. Maeda1, N. Yamamoto1, S. Fuchi1, T. Ujihara1, Y. Takeda1, T. Saka1, Y. Nakagawa1, S. Okumi1, M. Yamamoto1, T. Nakanishi1, H. Horinaka1, T. Kato1, T. Yasue2, and T. Koshikawa3

1Graduate School of Engineering, Nagoya University, 2Electrical and Electronics Engineering, Daido Institute of Technology, 3Graduate School of Science, Nagoya University, 4Faculty of Engineering, Osaka Prefecture University, 5Daido Steel Co., Ltd., 6Osaka Electro-Communication University

Transmission-type super-high brightness and high polarization photocathode

The current result
A transmission-type photocathode based on GaAs/GaAsP strained superlattice on GaP substrate

![Image of a transmission-type photocathode structure with various components labeled]

Using a short-focal-length lens, the spot size of laser light was greatly reduced. A GaAs interlayer was introduced to control the strain in the GaAs/GaP buffer layer.

GaAs/GaAsP strain-compensated superlattice for a high electron-beam current

The design of the superlattice
For a high electron-beam current: super-high brightness, and high polarization photocathode
For a high electron-beam current: (1) To apply a high-power laser as excitation light. (2) To increase quantum efficiency: To use strain-compensated superlattice for high crystal quality; to improve the crystal quality of the buffer layer; to decrease electron affinity of the superlattice.

![Image of a GaAs/GaAsP strain-compensated superlattice structure]

GalnAs/GaAsP strain-compensated superlattice for applying a high-power laser

Presently, Ti:sapphire laser is used as excitation light. The power is only 0.1-0.3 W. On the other hand, the power of some semiconductor lasers is larger than 10 W. Moreover, the semiconductor laser is smaller in size and its cost is cheaper than that of Ti:sapphire laser.

The wavelength of semiconductor lasers are 900-1000 nm. In order to adjust to the wavelength, GaInAs/GaAsP strain-compensated superlattice was fabricated on the GaAs substrate.

![Image of a GaInAs/GaAsP strain-compensated superlattice structure]

Pl measurement

The peak intensity of GaInAs/GaAsP superlattice is 30 times higher than that of GaAs/GaP superlattice. The defects in the GaInAs/GaAsP largely decreased.

High quantum efficiency strain-compensated superlattice on GaP substrate

Buffer layer on GaP substrate
To realize the strain-compensated superlattice on GaP substrate, a lattice-mismatched buffer layer is necessary. 500 nm GaAsP / GaP on GaP substrate.

![Image of a buffer layer structure on GaP substrate]

Strain-compensated superlattice
For a high quantum efficiency:
(1) For increase electron affinity, AlGaAs is used for well layer in the superlattice.
(2) AlGaAs well layer and barrier layer are strain-compensated on the buffer layer.

![Image of a strain-compensated superlattice structure]

Electron affinity (5150 meV) is by 80 meV smaller than that of the GaAs/GaAsP superlattice.

High electron affinity strain-compensated superlattice with high crystal quality buffer layer on GaP substrate will be fabricated soon.

Conclusion

On developing a transmission-type photocathode on GaP substrate with a GaAs interlayer, super-high brightness and high polarization electron beam was achieved.

For a high electron-beam current, we proposed two strain-compensated superlattice structures: (1) GaAs/GaAsP superlattice on GaP substrate was fabricated for using a high power semiconductor laser, and (2) a strain-compensated superlattice with AIXGaAs on GaP substrate was designed for a high quantum efficiency.

![Image of a high electron affinity strain-compensated superlattice structure]