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Direct Observation of Electron Jet from a Point Contact

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Direct observation of carrier motion in quantum nanostructures is quite important for the study of two-dimensional transport in physics as well as for quantum device characterization. Recently, there have been many reports concerning transport of electrons in devices having point contacts, in which conductance quantization, electron focusing, or electron interference effect have been observed[1-4]. However, in these measurements current or voltage change through the devices have been measured, and energy or density distribution of electrons have been studied only by computer simulations[5]. In this work we report on a novel method for observation of electron flow by using micro-photoluminescence (μ-PL) measurements[6].

Samples including a point contact were prepared by molecular beam epitaxy (MBE) growth of an InGaAs/GaAs quantum well with a thickness of 10 nm, formation of a slit by wet chemical etching, and re-growth of GaAs by MBE for embedding the etched grooves (see Fig. 1). Carrier density and mobility of the unetched quantum well at liquid nitrogen temperature were 4.6×10^{15} m^{-2} and 3.0 m^2/Vs, respectively. μ-PL measurements at about 18 K were carried out by illuminating a He-Ne laser light on the part around the point contact homogeneously, and change of PL image from the illuminated area was observed by a charge coupled device (CCD) camera as a function of bias voltage.

Majority electrons accelerated by the electric field in the point contact have large wavenumber, while minority electrons and holes generated by laser light illumination have small wavenumber. Therefore, it is expected that at the region where electrons have large velocity, probability of electron-hole recombination becomes small and PL intensity at the region decreases. A photograph in Fig. 2 is a composite image obtained by subtracting the PL image at a bias voltage of 0.75 V from that at a zero bias voltage together with the sample image. As we predicted above, electron flow from the point contact was visually observed.

In conclusion, we successfully observed electron jet from a point contact by μ-PL measurements. It is considered that this kind of method is promising for estimation of carrier transport in quantum nanostructures.

References

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[1] Wees et al., Phys. Rev. Lett. **26**, 848 (1988).
[2] Houten et al., Europhys. Lett. **5**, 721 (1988).
[3] Spector et al., Appl. Phys. Lett. **56**, 1290 (1990).
[4] Yacoby et al., Phys. Rev. Lett. **66**, 1938 (1991).
[5] Fasol et al., in *Proceedings of 22nd International Conference on the Physics of Semiconductors*, Vancouver (1994) pp.1645.
[6] Nagamune et al., in *Proceedings of 22nd International Conference on the Physics of Semiconductors*, Vancouver (1994) pp.1835.

Figures

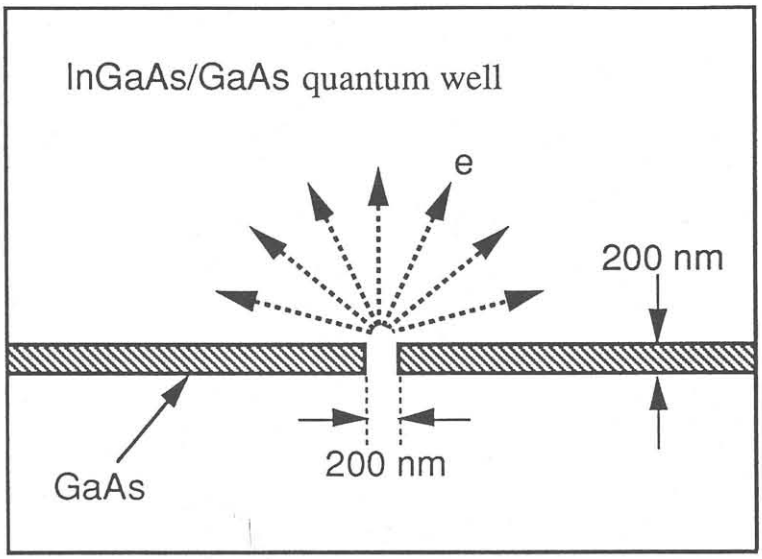

Fig. 1 A schematic illustration of the sample studied in this work.

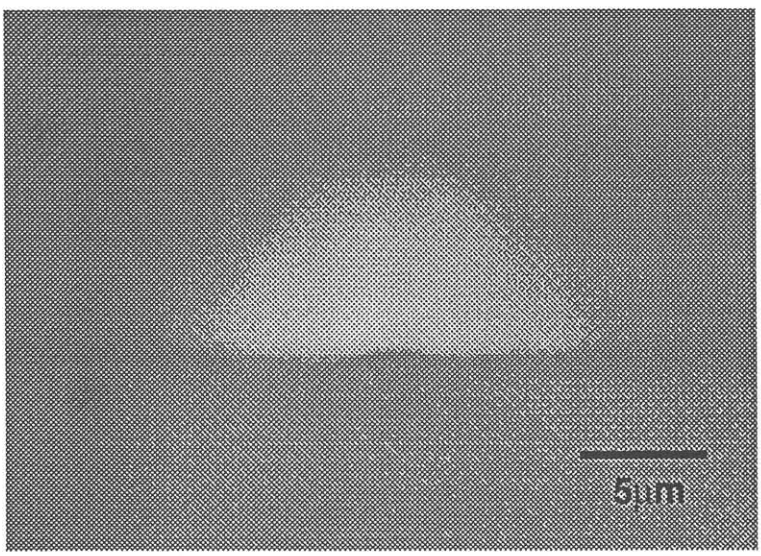

Fig. 2 A plan-view image obtained by subtracting the PL image at a bias voltage of 0.75 V from that at a zero bias voltage together with the sample image