Various studies on quantum point contacts (QPCs)
量子ポイントコンタクト（QPC）に関する様々な研究

We fabricated a vertically-coupled quantum point contact (QPC) with a triple-gate (two split-gates and one center-gate) and a back-gate starting from bilayer GaAs quantum wells. We demonstrated that the coupling characteristics between the two QPCs can be electrically controlled by tuning the voltages applied to the four gates. Unintentionally induced misalignments can be rectified by carefully controlling the voltages applied to the gates. All electrical control of the coupling characteristics in a vertically-coupled QPC will pave the way to a new understanding of electron-electron interactions and spin-related phenomena in the coupled QPCs [1].
The triple-gate structure is attractive even when it is applied to the single quantum well. Comparison between devices with and without a center gate revealed that the center gate, even at zero bias, affects the surface potential and significantly enhances the 1D confinement [2], resulting in clear quantization even for relatively low mobility two-dimensional systems [3]. It is noteworthy that the positive bias to the center gate enhances Fabry-Perot type interference reflecting abrupt change of the saddle point potential at the both ends of the QPC [3].
We also found an unusual increase of the conductance with temperature (high temperature range where quantization disappears) in clean QPCs where conductance becomes larger than the quantized conductance [4]. A positive magnetoresistance arises at the same time. A model accounting for electron-electron interactions mediated by boundaries (scattering phenomena like Friedel oscillation) qualitatively describes the observation.

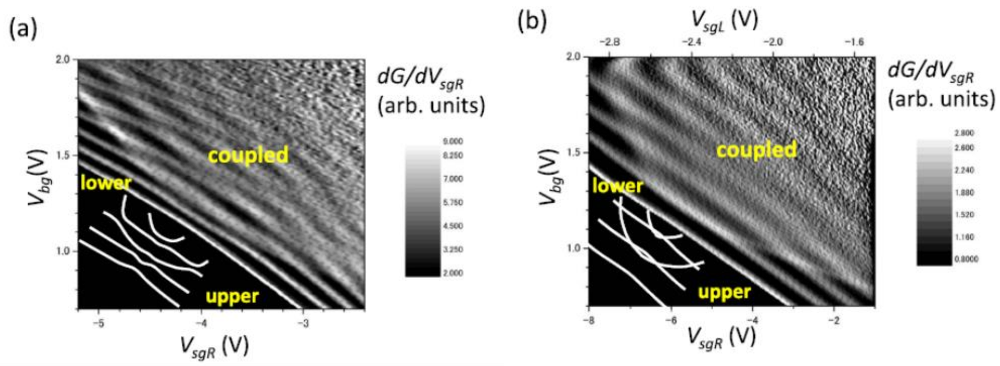

Fig. 1 Transconductance (dG/dV_{sgR}) data presented as a gray-scale plot. V_{sgR} and V_{sgL} means voltage applied to the right- and left-side split gate, respectively. The applied voltages to the split-gates are carefully controlled to satisfy the alignment condition of the two wires in (b). The 1D subbands are anticrossing even with different 1D subbands' index in (a) reflecting misaligned wires, whereas subbands only with the same index are anticrossing in (b). Insets show the schematic subband diagrams.

Representative publications:

1. S. Ichinokura, T. Hatano, W. Izumida, K. Nagase, and Y. Hirayama, "Electrical control of tunnel coupling between vertically coupled quantum point contacts", Appl. Phys. Lett. 103, 062106 (2013).
2. H. M. Lee, K. Muraki, E. Y. Chang, and Y. Hirayama, "Electronic transport characteristics in a one-dimensional constriction defined by a triple-gate structure", J. Appl. Phys., 100, 043701 (2006).
3. S. Maeda, S. Miyamoto, M. H. Fauzi, K. Nagase, K. Sato, and Y. Hirayama, "Fabry-Perot interference in a triple-gated quantum point contact", Appl. Phys. Lett., 109, 143509-1-4 (2016).
4. V. T. Renard, O. A. Tkachenko, V. A. Tkachenko, T. Ota, N. Kumada, J. –C. Portal and Y. Hirayama, "Boundary-Mediated Electron-Electron Interactions in Quantum Point Contacts", Phys. Rev. Lett. 100, 186801 (2008).