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Negative Differential Resistance of InGaAs/InAlAs Quantum Wire FET on InP (311)A Substrate

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Semiconductor quantum wires (QWR) have been attracted attention lately for various applications in novel electronic and optical devices. Selective growth of III-V semiconductors on non-planar substrates has been accepted as a promising method for fabricating QWRs. In this study, we report for the first time the novel formation of narrow (10x20nm) InGaAs/InAlAs QWRs on a (311)A InP V-grooved substrate. Figure 1 shows a cross-sectional view of the trench-type InGaAs QWR grown on a InP (311)A V-grooved substrate perpendicular to [01-1]. The structure of trench-type with (111)A and (331)B facets have formed in the InAlAs barrier layer growth, which were successfully fabricated under an As_2 flux. Under an As_4 flux, however, trench-type structure cannot be formed. The luminescence and good optical properties for the trench-type QWRs have confirmed with cathode-luminescence measurements and photoluminescence spectra. We also demonstrate the NDR characteristics including high peak-to-valley ratio and low onset voltage in a trench-type InGaAs QWR-FET on a (311)A InP V-grooved substrate. Figure 2(a) shows the I_d-V_{ds} characteristics of the QWR-FET at room temperature, and this data indicate good saturation characteristics. Figure 2(b) shows the I_d-V_{ds} characteristics at 40K. The NDR spectra are clearly observed in the range of V_{ds}=0.12V to V_{ds}=0.19V by increasing V_g. Trench-type InGaAs QWR-FET indicate clear NDR characteristics with a low onset voltage (V_{NDR} = 0.12V) and a high peak to valley current ratio (PVR=4.3) at 40K. Such a low onset voltage (V_{NDR}) has not been observed in the NDR devices previously reported.

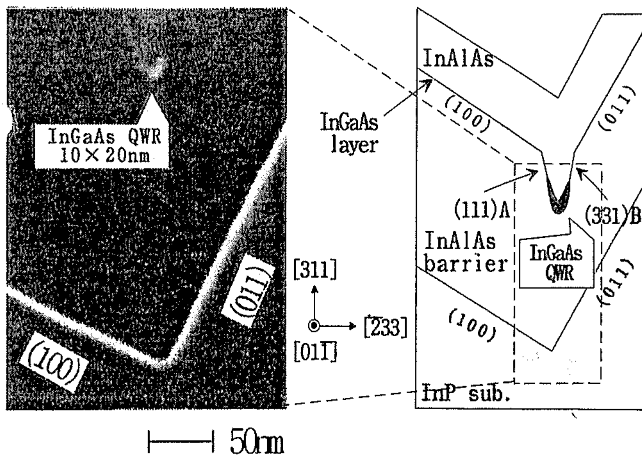

Fig. 1: Cross-section of a QWR including a schematic of the structure. The trench structure of the InAlAs barrier layer consist of (111)A and (331)B facets grown under an As_2 flux.

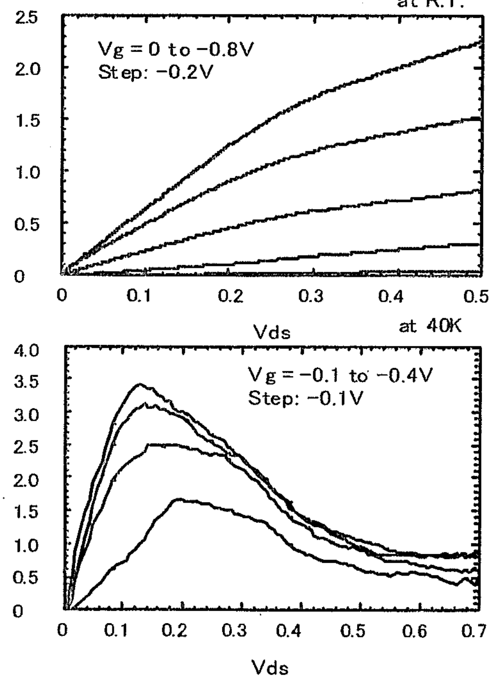

Fig.2 (a) I-V characteristics of a trench-type InGaAs QWR-FET at R.T, and (b) NDR characteristics are clearly observed at 40K