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Moleculr Beam Epitaxial Growth of Quantum Wire by Tilted Superlattice Method*

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Structures with quantum confinement of charged carriers in low dimension such as quantum wire (QWW) and quantum dot (QD) have attracted much attention in recent years as a results of new physical phenomena and potential device applications. Most of these low dimensional structures have been made by lithographical methods. But, the lateral dimension in such structures has been yet too large. Recently, tilted superlattice (TSL) on the vicinal substrate surface was suggested as a new means of growing QWW [1]. In TSL, the lateral dimension is in nanometer range which is comparable to the vertical dimension. Fig. 1 shows how TSL QWW is formed on stepped surface .

In this work, the molecular beam epitaxial growth of two QWW's using TSL method is reported. Sample 1 was grown on GaAs:Cr,O substrate which is tilted by 3 degree from (100) surface toward [010] directions. In TSL layer, ½ monolayer (ML) of GaAs and ½ ML $Al_{0.5}Ga_{0.5}As$ was grown repeatly for 19 period to form 30Å x 60Å GaAs QWW in $Al_{0.5}Ga_{0.5}As$ barrier. In order to separate GaAs/AlGaAs layer, we used migration enhanced epitaxy (MEE) which is alternate beam growth of (Ga,Al) and As. The growth temperature is 600℃. The growth interuption is introduced on each interface. Sample 2 was grown on InP:Fe substrate which has the same tilting to sample 1. It has 30Å x 30Å InAs QWW in AlAs barrier. The growth temperature is 430℃.

Transmission electron microscope (TEM) of Sample 2, as shown in Fig. 2, shows the tilted steps of $(InAs)_1/(AlAs)_2$ superlattice barriers clearly. It also shows two distinct dark lines, which may be identified with 2 QWW's out of 3 we have grown. But, no clear wire structure can be obersved.

Also performed on the samples were Photolumineacence(PL), PL exitation (PLE) and reflectance spectroscopies. PL spectrum of Sample 1, shown in Fig. 3, has a peak at 1.917 eV, which can be identified with QWW. But, contrary to theory [2], we observed little polarization dependence of PLE spectrum. Instead, clear polarization dependence was observed from the reflectance spectrum, which is shown in Fig. 4. Comparing to little polarization dependence of single quantum well structure, this provides a clear and positive evidence on the formation of QWW.

Conclusively, we successfuly grew QWWs on the vicinal substrate using TSL method. TEM, PL and polarization dependence reflectance spectroscopic analyses support the presence of QWW.

[1] P.M.Petroff, A.C.Gossard, W.Wiegmann, Appl. Phys. Lett. 45, 620 (1984)
[2] M.Tsuchiya, P.M.Petroff, L.A.Coldren, Appl. Phys. Lett. 54, 1690 (1989)
* This work is supported in part by MOE.

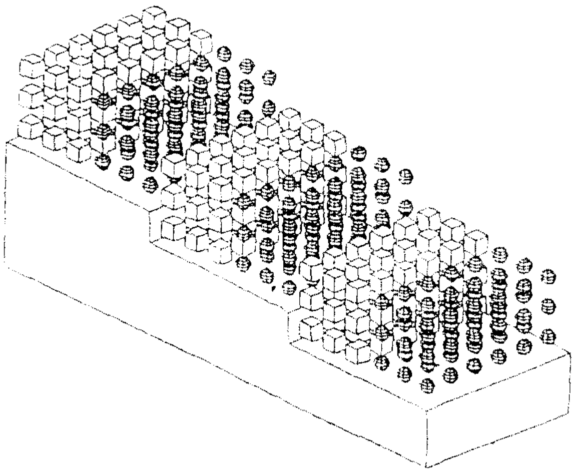

Figure 1 Growth of QWW by TSL method : repeated half monolayer growth

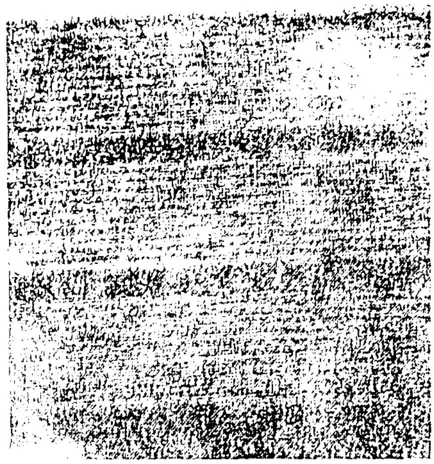

Figure 2 TEM micrograph of InAs/AlAs QWW

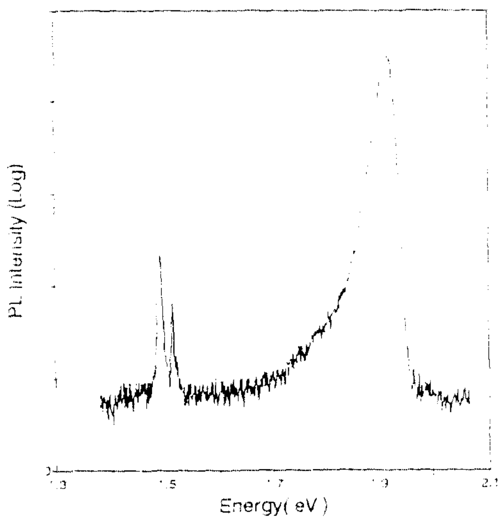

Figure 3 PL spectrum of $GaAs/Al_{0.5}Ga_{0.5}As$ QWW

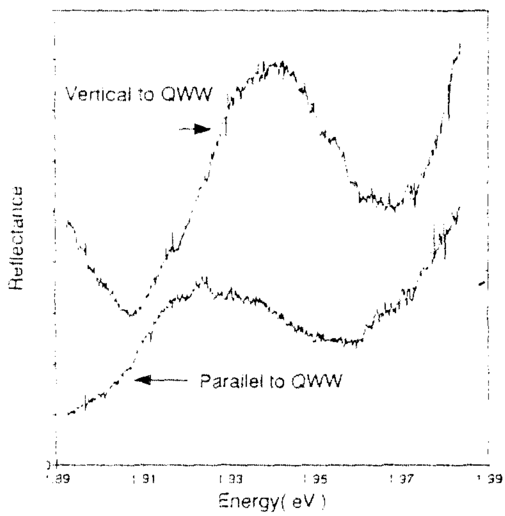

Figure 4 Polarization dependence of reflectance spectrum at $GaAs/Al_{0.5}Ga_{0.5}As$ QWW