Comment on "Optical Anisotropy in a Quantum-Well-Wire Array with Two-Dimensional Quantum Confinement"

Anisotropic photoluminescence excitation (PLE) spectra from a GaAs quantum well (QW) with a tilted superlattice (TSL) barrier were reported and ascribed to a quantum-wire electronic structure [1]. Also reported were the expected, nearly isotropic PLE data from an ordinary QW. Contradictory theoretical results were later reported [2,3] for the QW/TSL, referred to here as a corrugated QW (CQW). During our subsequent work at the same facilities, the sources of discrepancy began to appear. Here we summarize the theoretical issues and our results: We conclude that the anisotropic behavior was dominated by experimental artifacts.

The data were well explained using Eq. (1) of Ref. [1]. The model, however, did not include quantum mechanical interference, and to do so gives polarization-independent expression [2]. Quantitative predictions require including valence band mixing and the actual CQW geometry and compositions. Citrin and Chang have done this with a tight-binding calculation and found that an ideally formed TSL, with no AlAs in the GaAs corrugations, will show similar polarization effects [3]. However, a small amount of TSL intermixing pushes the hole wave functions out from the corrugation and greatly reduces the polarization anisotropy [3]. We expect the (AlAs)/(GaAs) TSL to be very intermixed [4] and to be closer instead to an $(Al_{0.55}Ga_{0.45}As)/(Al_{0.45}Ga_{0.55}As)$ TSL, consistent with the micrograph of Ref. [1]. In hindsight, we thus expect virtually no PLE anisotropy.

While performing polarization-dependent luminescence measurements with the same apparatus [4], we discovered that the cryostat window previously used to excite the CQW is birefringent. At these wavelengths the window assembly rotates the polarization of light passing through it by 90° over only a 20-nm spectral range.

This birefringent rotation should be unimportant in PLE, though, if the above CQW has isotropic absorption. The polarization arises from the experimental setup itself, given in Fig. 1(c) of Ref. [1], where the excitation beam is incident at 65° from the sample normal. Oblique transmission across the air-sample interface is quite polarization dependent, and has recently been used in a QW characterization technique [5]. Pumping at an oblique angle will thus change the excitation power when the polarization angle is changed. The birefringent window rotates the excitation polarization as the wavelength is varied, thus modulating the PLE signal. Significantly, the reference QW and the CQW spectra in Fig. 2(b) of Ref. [1] have PLE features at different wavelengths, so the apparent polarization dependences are necessarily different.

To check the hypothesis that the observed anisotropy was due to a birefringent rotation and oblique incidence, we performed PLE spectroscopy on an isotropic 5-nm GaAs QW using the same cryostat window and configuration. Our results in Fig. 1 bear a striking similarity to Fig. 2(b) of Ref. [1]. Thus we conclude that there is no evidence of confinement to one dimension in the original Letter.

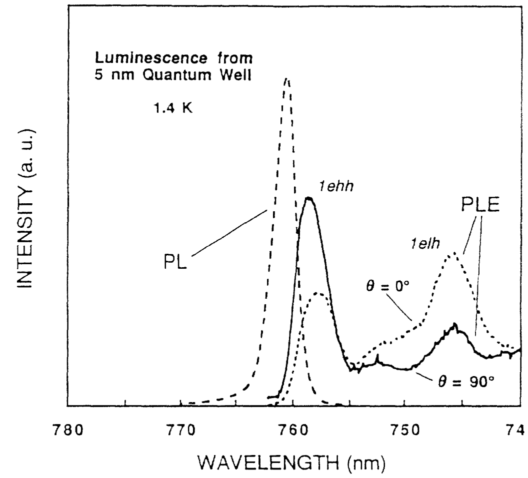

FIG. 1. PL (dashed lines) and PLE (solid and dotted lines) spectra of a 5-nm quantum well. The exciting light polarization angle θ is defined as in Ref. [1].

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