양자우물 — 양자선 상전이 현상의 광양자테 레이저

Quantum well — quantum wire phase transiton of photonic quantum ring laser

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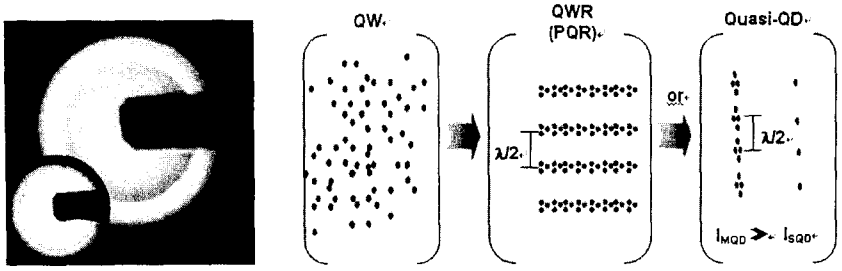
The GaAs semiconductor whispering gallery modes, produced in the peripheral Rayleigh band region of $W_{Rayleigh} = (\phi/2)(1-n_{eff}/n)$, exhibit novel properties of ultralow thresholds open to nano-ampere regime associated with photonic quantum ring (PQR) production (Fig 1 (a)) [1]. The PQR phenomena are associated with a photonic field-driven phase transition of quantum well (QW)-to-quantum wire (QWR) and hence the photonic (non-de Broglie) quantum corral effects [2], on the Rayleigh cavity confined carriers in dynamic steady state, occur as schematically shown in Fig. 1 (b).

Threshold current data at room temperature for the PQR lasers of various sizes, as shown in Fig. 2 (curve A), follow a simplified formula derived for $\lambda/2$ spaced concentric quantum ring arrays [1]. We further note that the actual threshold data are far off from the curve B (Fig. 2) obtained when the Rayleigh band is conventionally assumed to be a regular QW plane.

A possible explanation for the fermionic QW-to-QWR phase transition condensation comes as follows : Electronic quantum corral work [3] suggests a local density of state (LDOS) along the peripheral Rayleigh toroid in the first place. Onset of the emission, even with a small injection, then tends to laser-trap and order the carriers in the cavity [4]. Of course the fermionic condensation is for the average carriers in dynamic steady state since the e-h recombination process has already begun [2]. Fig. 2 shows some early data for the PQRs undergoing a backward QWR-to-QW phase transition as the device temperature is raised. The backward transition data were taken in the temperature range of 20° ~ 130° C.

We finally note that a wavelength-size PQR which carries only a couple of standing modes may result in few-QD states, and properly pinned PQR modes from a 2 QD states (Fig. 1 (b)) will give a dipole radiation, useful for a single photon source application.



(a) (b)

Fig. 1. (a) Microscopic pictures, (b) QW-to-QWR and QWR-to-QD phase transition, Quasi-QD can be either multi-QD or single QD states.

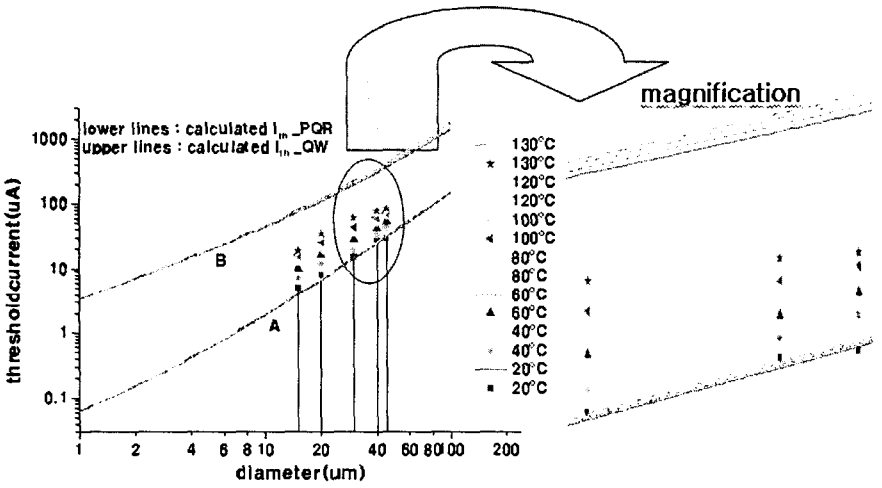


Fig. 2. A backward QWR-to-QW phase transition as the device temperature is raised

Reference

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