

양자테 레이저와 광파 질서
Quantum Ring Laser and Lightwave Ordering

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The smart pixel technology as the flip-chip integration of CMOS circuits with photonic devices like the VCSEL (Vertical Cavity Surface Emitting Laser), is the latest major efforts of realizing high-density chip-level optoelectronic integrations so that the massive free-space parallel optical processing schemes are realized in the next-generation multi-THz optical internet traffic. However, currently available 8x8 VCSEL arrays are simply too small scale integration to be meaningful for real system applications. Moreover the VCSEL array's drawback associated with the device heating due to the injected current, let alone the polarization problem, has recently triggered various oxidized-constriction-layer techniques leading to minimum injection currents, which then make routine chip fabrication steps rather difficult.

As a breakthrough for the above efforts, we have recently developed a photonic quantum ring (PQR) laser, operating with micro-ampere current and with quantum wire-like temperature behavior so that the device does not suffer from the nightmare of spectral wandering at operating temperatures. [Phys. Rev. Lett. Vol.82, 536, 1999]

The anomalous PQR properties are actually new aspects of the old Rayleigh whispering gallery, observable in optical domain, and are interpreted as follows[to be published]:

- [1] The 1-dimensional quantum-wire formation at the peripheral region of the 2-dimensional active quantum well disk is possible due to the so called quantum corral effect as observed several years ago by Eigler et al. at IBM.
- [2] The PQR's helical bundle of multi-angle resonance becomes realizable because the Rayleigh toroid provides 3-dimensional total-reflection space for the complex manifold resonant paths. Every path is then confined in the same gallery band in the quantum well plane, and also experiences an equivalent gain vertically since the same gain area is always swept by every path. It means that the given amount of available carriers are always consumed thoroughly for any helical propagation angle

due to the transverse, as well as helically longitudinal, lightwave ordering and trapping of the carriers [Proc. IEEK Summer Conf.'99, pp309-314, Mokpo, 6/1999].

- [3] The half-wavelength-period lightwave ordering and trapping of the carriers are very unique nature of the PQR's whispering gallery cavity, and can be understood according to the formation of the cavity standing modes and the so called gradient trapping force as discussed by Letokov and Minogin[Phys. Report Vol73, 1, 1981].
- [4] The above PQR devices are being improved for nano-laser fabrication, ring cavity chaos was also observed in the pre-threshold regime recently [Proc. COOC'99, pp285-286, Kwangjoo, 5/1999] , and esp. the lightwave ordering phenomena are under intense investigation.