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A NEW SPECTROSCOPY BASED UPON 3D PHOTONIC QUANTUM RING LASERS FOR NON-INVASIVE AND PORTABLE BRAIN/HEART DISEASE DIAGNOSTIC TECHNIQUES

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The photonic quantum ring (PQR) lasers consist of cylindrical mesas of multi-quantum well (MQW) active region between top and bottom DBR structures. PQRs create the resonant double helix standing waves (CW and CCW) of the 3D donut cavity because it is 3D version of Lord Rayleigh's 2D whispering gallery mode (WGM). The room-temperature PQR thresholds are in the micro-ampere range for active diameters less than 20μm. The GaAs PQR then exhibits 3D spectra of apex-angle-dependent blue-shifts in the 20–30 nm range (795-765nm major peaks) as shown in Fig.1, implying that it is possible to extend continuously the PQR's tunable frequency ranges in 20nm steps from 700 to 980nm, to cover almost all interesting ionic IR frequency ranges, quite different from the usual functional near-infrared spectroscopy (FNIRS) being confined to single or few frequencies, for instance, for oxy/deoxy hemoglobin studies. Employing multiple 3D angle-tuning PQR measurements, we may go to hemodynamic or other ionic transport studies for various brain/heart diseases in the near future.

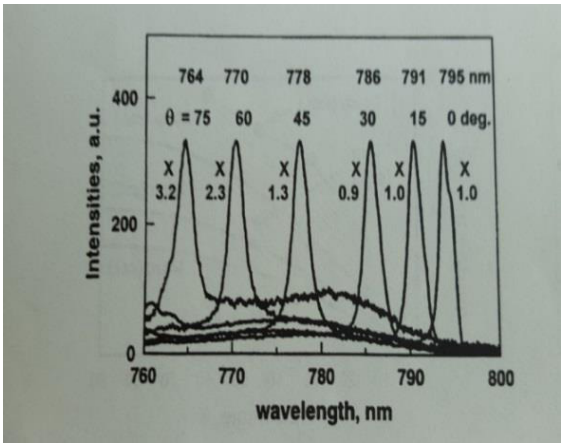

Figure: 1 The active MQWs between the two DBR regions of the PQR device described in the beginning generate spectral peaks of both PQR and VCSEL resolved with a microprobe made of a tapered single modefiber and a spectrum analyzer (HP model 70951A), where the angle-dependent PQR emissions are inseparable from that of the VCSEL, because of data overlapping due to a monitoring microscope placed right above the device)

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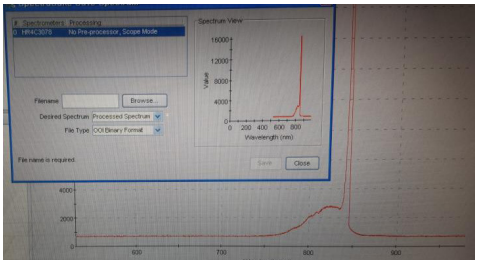

Figure: 2 A rough example can be seen from the first 845nm spectral data taken from cortical (frontal lobe) test measurements: A normally incident beam from PQR laser chip produced a reduced (~10%) beam

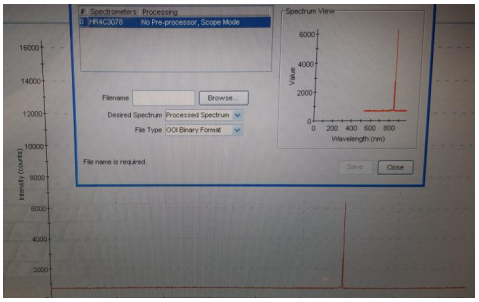

Figure. 3 A normally incident beam from PQR laser chip bounced back from front cranial region. Although not a good chip package for any cortical trials, we still tried since the current chip package of a 64x64 hole PQR array is proper for in vivo transmission tests with outer ear, and it seems promising. In doing so the emission power was moderately raised for the measurements and peak resolutions (incident 842 nm and outgoing 838 nm) are not yet clearly understood. Again this result is interesting although we cannot pinppoint certain ionic presence. We have to improve the situation further for example with pulsed operations

Recent Publications

1. B H Park, S D Baek, J Y Kim, J Bae and O Kwon (2002) Optical sensing by using photonic quantum ring lasers and resonance enhanced photodetectors. Opt. Eng. Vol. 79, pp. 1339-1345.
2. B H Park, J Bae, M J Kim, and O Kwon (2002) Chiral wave propagation manifold of the photonic quantum ring laser. Appl. Phys. Lett. Vol. 81, pp 580-582.
3. C Ahn, H Y Kang, and O Kwon (1998) Angle-dependent multiple-wavelength radial emissions in a toroidal microcavity: (A photonic quantum ring laser), SPIE, Vol. 3283, pp.241-251
4. J C Ahn et al (1999) Photonic Quantum Ring. Phys. Rev. Lett. Vol. 82, No.3 pp 536-539.
5. J Bae, J Lee, Kwon, and V G Minogin (2003) Spectrum of three-dimensional photonic quantum-ring microdisk cavities: comparison between theory and experiment. Opt. Lett. Vol. 28, No. 20, pp 1861-1863

Biography

O'Dae Kwon is a Professor Emeritus at POSTECH. He received his BS from Seoul Natl. Uniersity in 1969; MS in 1975 and PhD in 1978 from Rice University; He has worked at Cornell University from 1978-82, at Dow Research Center from 1983-86 and currently at POSTECH since 1986. He visited AT&T Bell Lab during 1993-94, UCL in 2000-01. He won the Scientist of the Year 1998 in Korea and Best paper award, IEEE NMDS 2007. He wrote 2 Phys Rev Letts and over 70 papers (30 papers on PQR lasers). He is interested in Optics and Quantum Devices and Theories.

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