UNIVERSITI TEKNOLOGI MARA

OPTICAL MICROSPHERE AND MICROBOTTLE RESONATOR FOR SENSOR AND LASER APPLICATION

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ABSTRACT

Micro-resonators have been attracting attention due to their many advantages including their ability to confine light with high quality factor (Q) and in a small modes volume. They are typically associated with circular-path resonant cavities such as micro-ring, micro-disc and micro-toroid geometry and these resonators can support whispering gallery mode (WGM) operation by creating continuous internal reflection at specific resonant wavelengths. According to the geometrical optic principle, a WGM can be represented by an optical ray transmitted exclusively near the micro-resonator surface due to grazing-angle total internal reflection. When light is evanescently coupled into the micro-resonator via a microfiber, very narrow resonance dip with a full width half maximum (FWHM) on a level of pm appears in the transmission spectrum. The optical WGM device can be applied in many areas including optical sensing and lasing. The aim of this research is to develop a micro scale of resonator as a sensor and laser technology which can create devices that are extremely small sized, ultra-lightweight and have the potential to be manufactured at low cost. In this thesis, two types of resonator micro-sphere (MSR) and micro-bottle (MBR) are fabricated using silica fiber with "soften and compress" method. The MSR and MBR is then characterized by employed some range of wavelength from tuneable laser source. The resonance depth is captured for every MSR and MBR condition. The Q-factor was defined by calculation, which used to identify the quality of resonance depth. The MSR and MBR was then used as sensor to sense different relative humidity (RH). For instance, as the RH increases from 40% to 100% the microfiber 8μm coupled with MSR shows sensitivity of 0.2840 dB/% with a slope linearity of more than 97.80% and a limit of detection of 19.132%, while for MBR produces sensitivity 4.7% better than MSR, with a slope linearity of more than 99.46% and a limit of detection of 18.3781%. It is found from the results that MBR has high efficiency regarding humidity sensing than MSR. In this study, formaldehyde (CH_2O) liquid sensor also has also been demonstrated using the MBR coupled with 8μ tapered fiber as a probe. The sensor performance without MBR was also investigated. As concentration of CH_2O liquid was tested within 0 to 6 %, the MBR sensor showed a better sensitivity of 0.09 dB/% with a linearity of 95.3% compared to no MBR. On the other hand, a MSR deposited with tungsten disulphide (WS2) as absorber was used to demonstrate a dual-wavelength Q-switched Erbium-doped fibre laser (EDFL). The MSR also functioned as a wavelength selective filter for realizing a dual-wavelength Q-switched operation at 1554.0 nm and 1560.7 nm. Stable pulse train is observed within pump power of 104.6 mW to 145.8 mW with maximum repetition rate of 85.1 kHz corresponds to shortest pulse duration of 3.47 μs. The maximum pulse energy of 131.4 nJ was obtained at 145.8 mW pump power.

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