RESONANCES SPECTRUM OF THE FIBER-COUPLED MICROSPHERE WHISPERING GALLERY MODES AND MICRORING RESONATORS FOR ALL-OPTICAL SWITCHING

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1. Letter of Report Submission

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PENERIMAAN BORANG TAMAT PROJEK PENYELIDIKAN (RAGS)
TAJUK PROJEK: Resonance Spectrum Of The Fiber-Coupled Microsphere Whispering Gallery Modes

Dengan segala hormatnya perkara di atas adalah dirujuk.

2. Adalah dimaklumkan, Pusat Pengurusan Penyelidikan (RMC) telah menerima satu (1) salinan asal borang tamat projek bertajuk seperti di atas daripada pihak tuan. Pihak RMC mengucapkan setinggi-tinggi tahniah. Sehubungan itu, projek penyelidikan pihak tuan telah didaftarkan sebagai **TAMAT**.

3. Pihak tuan perlu menghantar laporan akhir penyelidikan dalam bentuk satu (1) salinan cakera padat (CD) kepada RMC dalam tempoh satu (1) bulan dari dari tarikh surat ini.

4. Pihak RMC akan memuktamadkan dan menutup akaun penyelidikan tuan dengan kadar segera. Sebarang pertanyaan tuan boleh menghubungi Unit Pemantauan Penyelidikan RMC di talian 03-5543 7874 / 03-5544 2753.

Selaras dengan dasar penyelidikan UiTM disamping meningkatkan kesarjanaan akademik, pihak tuan adalah diharapkan untuk terus aktif memohon geran dan menjalankan penyelidikan berterusan.

Sekian, terima kasih.

Yang benar,

PROFESOR DR. HADARIAH BINTI BAHRON
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5.2 Enhanced Executive Summary

Interest in microsphere Whispering Gallery Modes (WGM) resonators has increased rapidly due to their versatility in terms of materials and dopants for a variety of passive and active device. Furthermore, microsphere resonators have the potential to add significant functionality to planar light wave circuits when coupled to waveguides where they can provide a range of unique functions, such as all-optical switching, wavelength filtering and lasing functions. WGM occurs at particular resonant wavelengths depending on the size of the resonator. At these particular wavelengths, light undergoes total internal reflection at the surface of the resonator creating resonances in the transmission spectrum of the resonator. The technique to couple light into WGM and to excite the associated optical modes are based on evanescent coupling and excitation structure like tapered fibers. This excitation technique require a nanoscale gap between resonator and the exciting structure whose dimension is crucial to reach critical coupling.

In this research, the WGM microsphere WGM is fabricated using Fiber Arc Fusion Splicer and Corning® SMF-28® ULL optical fiber is used as the material. The resonances spectrum of the WGM is investigated using Tunable Laser Source (TLS) and Optical Spectrum Analyzer (OSA). The experimental results are then analyzed. We observe an interesting phenomenon that is the resonance peaks in the light intensity spectrum curve is very sharp and the intervals between two successive peaks are very stable. Moreover, the resonance frequencies shift with the changes of the microsphere size and the optical properties of the surrounding medium. The research will pave the way on how to control WGM parameters in order to obtain the desired resonance spectrum and the output from this research has a potential to produce a high-Q factor and high finesse WGM microresonators.

Here, we also report a comprehensive treatment of parametric effect in a symmetrical add-drop silicon microring resonator with 5 μm radius operating within telecom wavelength spectrum or C-band ranging from 1530 nm to 1565 nm. The power outputs of the system are analyzed by using transfer matrix method. The FSR and FWHM have been optimized. Silicon microring resonator (MRR) provides a new platform to form the building block for all-optical switching devices. However, one of the critical problems in achieving a real practical all-optical switching devices is the requirement for a strong material nonlinearity. A strong material nonlinearity is crucial in order to achieve a low switching power. However, silicon-based all-optical switches require extremely high switching power due to its relatively weak nonlinear optical properties. To overcome this limitation, we have designed an all-optical switch configuration based on silicon microring resonator structure and demonstrated the switching operation based on the nonlinear effects induced by a soliton pulse. The soliton pulse induces free-carrier concentration through two-photon absorption (TPA) effect and this leads to enhance the refractive index change and enhance the nonlinearity of the silicon. Thus, the silicon microring resonator alters the nonlinear phase shift which is required for switching. The results demonstrated here will pave the way towards the new on-chip and chip-to-chip architecture and structure for low power and high bandwidth all-optical switch and optical modulator.

5.3 Introduction

In recent years, special attentions are paid to the Whispering Gallery Mode (WGM) microresonators and microring resonators (MRR), because they can well confine energy within their structures. WGM and MRR occur at particular resonant wavelengths depending on the size of the resonator. At these particular wavelengths, light undergoes total internal reflection at the surface of the resonator creating resonances in the transmission spectrum of the resonator. In order to couple light in or out of these resonators, the evanescent field of the WGMs has to overlap with the evanescent field of a phase-matched optical bus waveguide. The resonance shift is critically depended on the WGM parameters. This in-and-out coupling of WGM resonators is one of the major technological challenges and can only be achieved by an accurate fabrication. The geometry of the fabricated WGM need to be very smooth an clean to produce sharp spectra. To achieve the resonance, all the WGM and MRR parameters need to be optimized. At the end of the research, we expect to observe an interesting phenomenon that is the resonance peaks in the light intensity spectrum curve is very sharp and the intervals between two successive peaks are very stable. Moreover, the resonance frequencies will shift with the changes of the microsphere size and the optical properties of the surrounding medium. Silicon MRR provides a new platform to form the building block for all-optical switching devices. However, one of the critical problems in achieving a real practical all-optical switching devices is the requirement for a strong material nonlinearity. A strong material nonlinearity is crucial in order to achieve a low switching power. However, silicon-based all-optical switches require extremely high switching power due to its relatively weak nonlinear optical properties. To overcome this limitation, we have designed an all-optical switch configuration based on silicon microring resonator structure and demonstrated the switching operation based on the nonlinear effects induced by a soliton pulse. The soliton pulse induces free-carrier concentration through two-photon absorption (TPA) effect and this leads to enhance the refractive index change and enhance the nonlinearity of the silicon. Thus, the silicon microring resonator alters the nonlinear phase shift which is required for switching. The results demonstrated here will pave the way towards the new on-chip and chip-to-chip architecture and structure for low power and high bandwidth all-optical switch.