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# PSYCHIATRIC INVESTIGATION USING WGMs IN MICRORING CIRCUITS

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The use of an electrical probe is formed by whispering gallery modes (WGMs) of light within the coated microring circuits, in which the electrical signal is generated by trapped electron tunneling along the circular path of the coated microring circuit. The collection of electrons is formed within the WGMs, where in this study, a modified nonlinear microring resonator known as a PANDA ring resonator is coated by gold material and forms the mirroring circuit. The induced current (magnetic field) within the circuit occurs by the coupling effects between trapped electrons and coated ring, which can penetrate into the brain cells and transform to the required signals via the terahertz carrier for psychiatric investigations. The use of WGMs for 3D image construction using a PANDA conjugate mirror is also discussed, which is useful for thermal and imaging sensors.

*Keywords*: Optical health science; psychiatry; brain research; WGMs; bioelectronics; biomedical science.

## 1. Introduction

Optical devices and methods have been convincing tools for medical applications, where new methods of medical diagnosis and ways to treat diseases, for instance, the optical techniques have been employed to investigate the applications such as early detection

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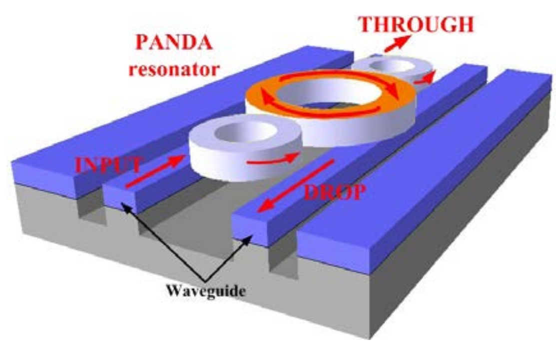
of breast cancer[1] and tissue monitoring and tomography,[2] which can be seen as the significant advances in the developments. Moreover, optical techniques have led to an ever increasing role of optics in the study and treatment of various problems in life sciences ranging from molecular level investigations to clinical treatment of patients.[3–6]

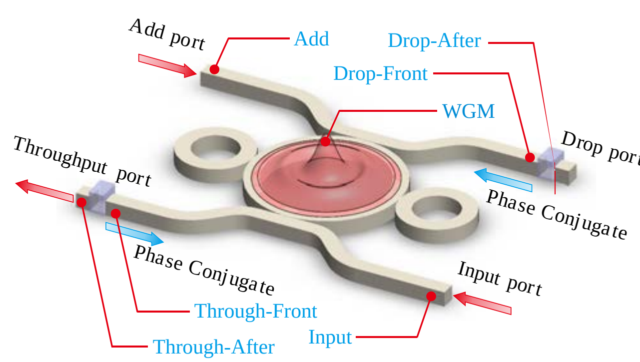
Psychiatry has been an important part of life because human performance and health depend upon individual human psychiatry, which have been the common problems of researches and investigations. The use of an electrical probe technique has been recognized as a good candidate in these investigations.[7] Particularly, one of the techniques is suitable for psychiatric investigation, which is a mobile technique,[8–12] which can serve the large demand of the world psychiatric problems. However, searching of new techniques remain. Recently, Yupapin has reported an interesting technique of light behaviors that use whispering gallery modes (WGMs) of light in a PANDA ring,[13] which can be easily applied for nerve/cells communications,[14] i.e., remote monitoring, where the use of microscale device based on microring resonator circuits has shown promising challenges. By using this proposed technique, mobile communication link of the psychiatric investigation can be formed via the radio frequency generated by the microring circuits, which will be detailed in the following paragraph.

WGMs of waves within a small scale optical device have shown interesting results and aspects, which are experienced by circular motions of varieties of waves, in which the WGMs can be formed within a circular path (orbit) of nonlinear optical ring resonator. In applications, the WGM is a form of potential energy that can produce force in all cases, in which the light wave potential can be used to trap an object or a small particle, which is available for many applications. Ashkin[15] has shown that light trapping tool known as optical tweezers (two laser beams) can be used to trap and move particles, which is also suitable for trapping other small particles such as atom, molecule, DNA, gene, ion, etc. WGMs of waves in nature have shown interesting results which can be useful for fundamental studies and applications in optoelectronics and nanoelectronics. Such WGMs usage has been studied and applied to trap atom by Wineland *et al.*[16] and Knight *et al.*[17] Yupapin *et al.* have confirmed that photons can be trapped (stopped) by using the WGMs in a microring resonator.[18] However, there are two more kinds of devices that can be used to trap light beams (atoms), the use of microcavity arrays performed by Yanik *et al.*,[19] and a nonlinear microring resonator by Yupapin *et al.*[20] for stopping light. Ang *et al.*[21] have also done the experiment to slow light using microresonators with a microring system.

Light pulse has been a promising tool in medical researches and investigations, especially, the terahertz light pulse that has the advantage of retaining the tissue undamaged upon penetration, which can be useful for nerve (cells) communications and cells imaging, molecular trapping and transportation, and medical treatment and therapy.[22,23] However, the light trapping probe can be used efficiently with specific targets by incorporating the hybrid transceiver[24] and molecular filter. Moreover, the use of coated ring resonator has also shown promising application,[18,25] in which the field strength generated by the coated antenna can be used as a therapeutic device.




(a) PANDA ring circuit



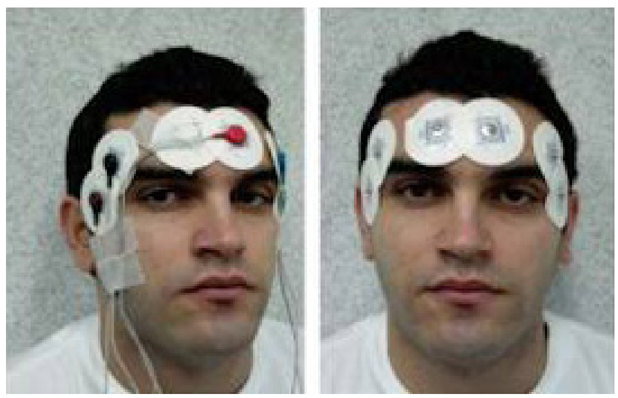

(b) PANDA ring conjugate mirror

Fig. 1. The modified add/drop filter structure are configured by two forms, where (a) ring circuit and (b) conjugate mirror.

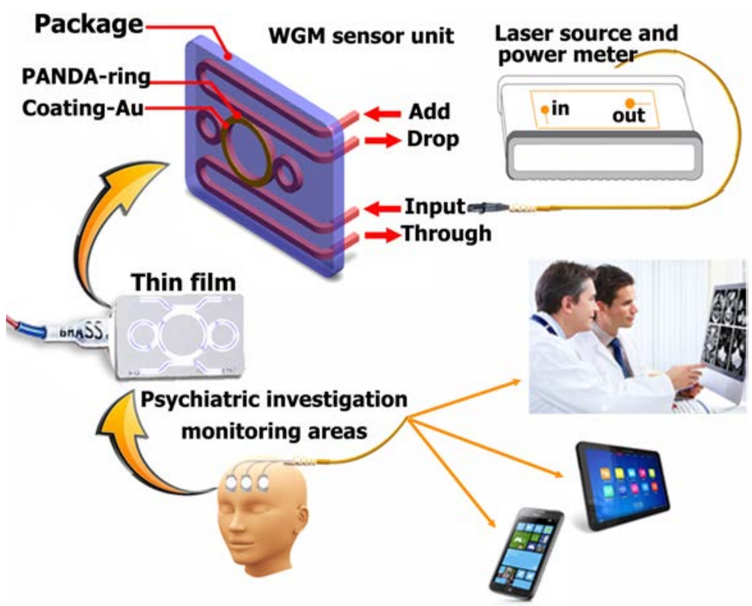
In this work, we design a new device by using a modified nonlinear microring resonator, which is made up of linear optical add-drop filter incorporating two nonlinear micro/nanorings on both sides of the center ring (modified add-drop filter). Here, the center ring is coated with Au or other conducting materials, e.g., Ag, Cu, etc. This particular configuration is known as a "PANDA" ring resonator[13,26] and is shown in Fig. 1. When the trapped particle which can be a single particle moves along the circular path of the coated waveguide, it induces the magnetic field and electrical current. In Sec. 2, we discuss the use of such quantities for micro-solenoid application.

## 2. Methodology

The use of electrical probe for medical application is as shown in Fig. 2(a), in which the exchange between facial muscle movement and electrical signal could be used to form the required information.[7] An electrical probe and brain cells connection system can be formed similarly in Fig. 2(b), in which the change in magnetic field (current) can be obtained by the coupled effects between trapped electron and coated waveguide material, which introduces the change in WGMs shift and seen by the output port signal. On the other hand, the change in WGMs wavelength can be obtained by



(a)




(b)

Fig. 2. (a) Brain cells detection system by a volunteer with electrical probe,[7] (b) the proposed design system.

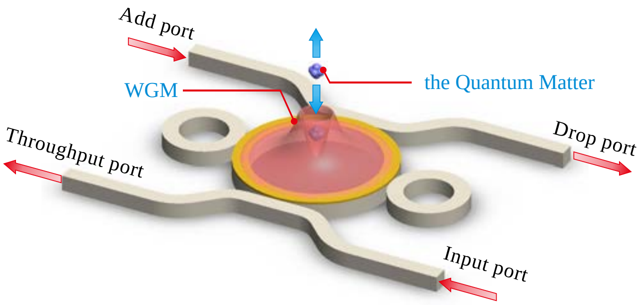



Fig. 3. Shows the use of a new device, the multipurpose solenoid can be constructed by changing the trapped particles to be molecules, DNA, gene, ion, etc.[27]

the coupled effects between the brain cells and terahertz light probe signals. Finally, the obtained data signals scan can be manipulated to form the required applications.

Figure 3 shows the trapping and moving electron along the center of ring, which is coated with Au and produces the propagation of magnetic field (B) (or current, I) around the ring. The surface plasmon tweezer is generated and the electric field within the waveguide induced, in which the quantum matter can be formed by the trapped particles, where the particle injection into the center ring (material) is formed via the tunneling particles as shown in Fig. 4, where a.1) and (a.2) are as shown in Fig. 3, so-called nanosolenoid. In this case, the waveguide surface is coated by the conducting materials, e.g., Au, Ag, Cu, etc.

In this paragraph, we will discuss the WGB results, which are obtained by using the Optiwave and MATLAB programs[18] and shown in Fig. 5. The device parameters are given in the figure captions.

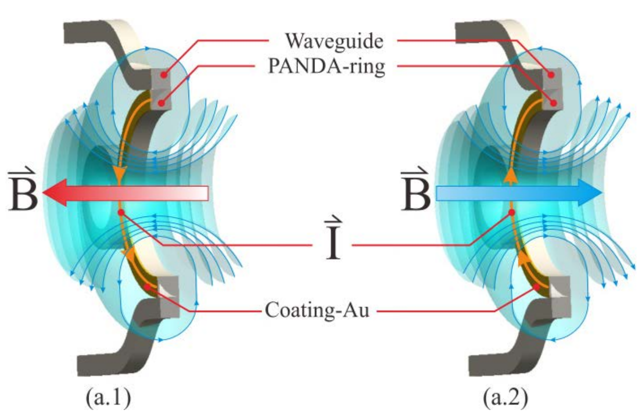
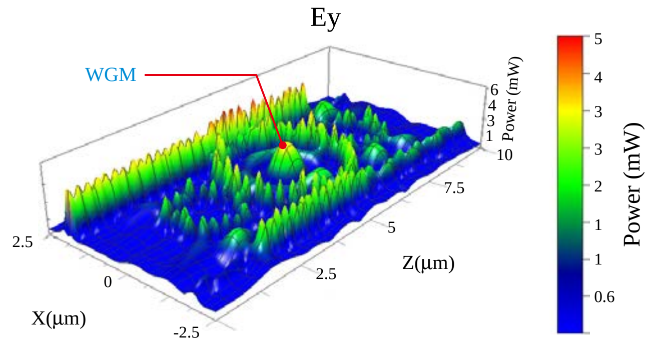
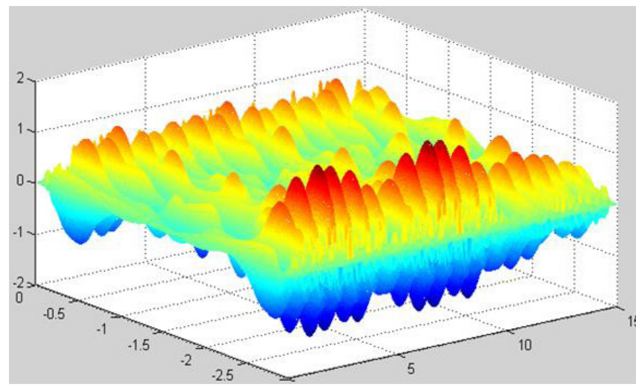


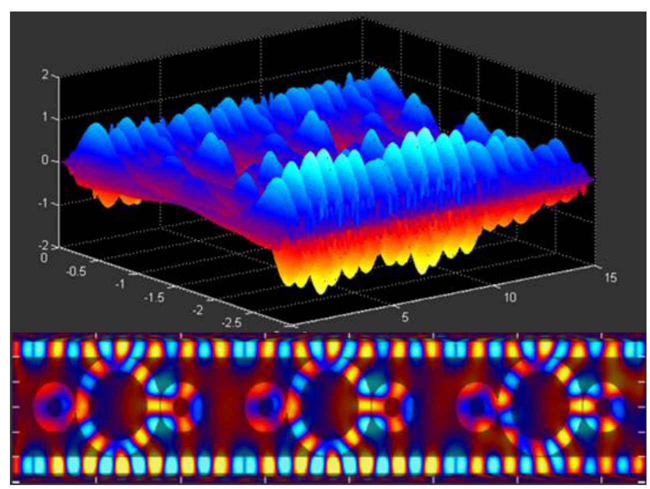

Fig. 4. Shows the direction of magnetic fields (B) and current (I), which can be controlled by the input signal such as Gaussian, soliton, etc.




(a)



(b)



(c)

Fig. 5. (a) result obtained by the Optiwave program, where WGM of light within a PANDA ring waveguide InGaAsP/In$P$, $R_1 = R_2 = 0.775\,\mu$m, $R_{\rm ad} = 1.565$, $A_{\rm eff} = 0.3\,\mu{\rm m}^2$, $n_{\rm eff} = 3.14$, $n_2 = 1.3 \times 10^{-13}\,{\rm cm}^2/{\rm W}$, $\kappa_1 = \kappa_2 = \kappa_3 = \kappa_4 = 0.5$, $\gamma = 0.01$, $\lambda_0 = 1550\,{\rm nm}$, (b) results obtained by the MATLAB program using the PANDA ring circuit, (c) result obtained by the MATLAB program using the PANDA ring conjugate mirror, where the surface plasmon tweezers (up) and potential well tweezers (down) with WGMs for brain cells detection probe.

The input wave (light) is a Gaussian/bright soliton (bright/bright soliton and a dark/dark soliton) pulse with a pulse width of 100 fs. The use of an optical trapping tool known as an optical tweezer for electron trapping and moving along the center ring can be formed. The tunneling particles can be generated and confined within a center ring by the WGB results as shown in Fig. 5. Figures 5(a) and 5(b) are the simulated results obtained by using the PANDA ring and PANDA conjugate ring and conjugate mirror, respectively, where the parameters used are given by the figure caption. By using the terahertz signal, light probe (electron probe) can penetrate into the brain/nerve cells, in which the coupling effects can be measured by the output probe at the drop port (terminal output port) of the PANDA ring, where the use of probe array with also be available for a large area, i.e., distributed sensing applications. In the case of PANDA ring conjugate mirror, the 3D image can also be constructed as shown in Fig. 5(b).

By using suitable optical wavelength and power, for instance, the terahertz (frequency or in term of wavelength) regime, the trapping particles can be penetrated into the brain tissue and linked to the brain cells, where finally the communication can be connected and the coupling effects measured. Moreover, the secure trapping particles can also be employed by using the optical capsule as shown in Fig. 6, in which the trapped particles can be securely trapped within the optical capsule. In this case, the capsule can open by capsule switching control, in which the WGMs can switch off after the optical capsule is induced into the PANDA ring via the add port, which can be used to form the on-off switching communication between the brain cells and tunneling signals, in which the communication between brain cells and WGMs can be useful for psychiatric investigation and therapy, where as in this case the specific atom/molecules can be brought into the brain cells, which is suitable for specific therapy.[27]

## 3. Light Probe and Brain Cells Investigation

The signals within the PANDA ring circuits can be generated in the form of light wave and magnetic field (or electrical current) as shown in Fig. 4 by the uncoated and coated waveguides, respectively. In this application, the WGMs frequency within the terahertz region can be generated and controlled, which is useful for the interaction between brain cells and WGMs, which results in the change in signal output and form the measurements.

By using the coated waveguide, the use of magnetic therapy can be formed by using the required magnetic field strength for each of therapeutic cases. Moreover, the use of trapped particles can also vary for specific therapy, in which the use of different particles and therapy can be performed. The large area of distributed light probes is as shown in Fig. 7,[28] where each pixel can connect to brain cells or tissues via the terahertz generated carrier, which can exchange the information and form the required data for brain investigation and therapy by using the signal analytical instruments.

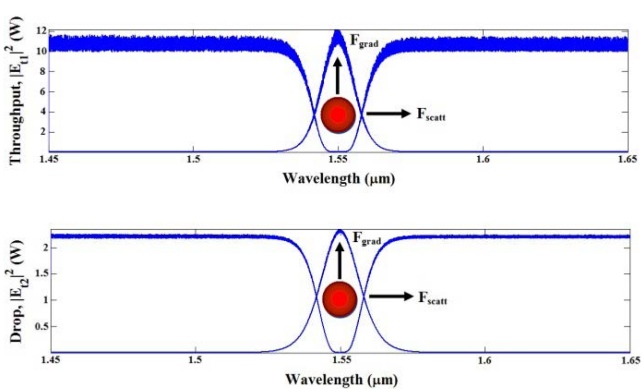



Fig. 6. Shows forms of tweezers called optical capsules, where $F_{\mathrm{grad}}$: gradient force, $F_{\mathrm{scatt}}$: scattering force for therapeutic use.

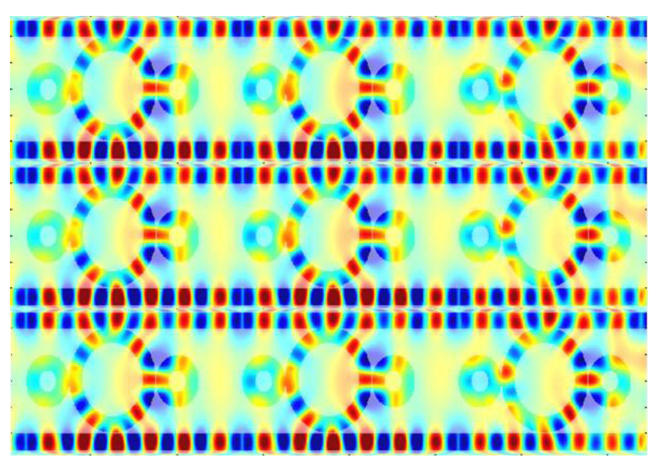


Fig. 7. 3D image model of the distributed sensors using WGMs for brain cells monitoring use.

## 4. Conclusion

The use of WGMs generated by light in PANDA ring circuits for medical applications, especially, psychiatric investigation has been proposed. By using the practical device parameters, the obtained simulated results have shown that the micro-magnetic field (force) can be constructed and controlled by the microring circuit system. Here, in applications, the use of a large area of thin magnetic films can be used to form a small current/magnetic probe for sensing applications. This can be used to probe the nerve/brain cells, in which the coupling current/magnetic field can be measured and output interpretation can be constructed for nerve/brain cells investigation, where the remote monitoring is also available by using the radio frequency oscillation. The use of WGMs for real 3D images is also available by using the same system, which is useful for thermal sensor and 3D imaging investigations (see Fig. 7), where $3 \times 3$ 3D pixels within the millimeter range can be used for large-area detection. In applications, the design device can be fabricated and used for realistic investigations, in which the device scale can be formed by a thin film device within the sub-millimeter range.

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