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Tissue Culture with 3D Monitoring by Distributed Ring Circuits

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Whispering Gallery Modes (WGMs) generated by light in a PANDA ring resonator, i.e. a small scale nonlinear optical device has shown the promising results and behaviors for interdisciplinary research subjects, in which most of them use the advantage of nonlinear coupling effects between center ring and two side rings [1] of the PANDA ring circuit. By using the practical simulation parameter and software known as an Opti-wave program, many applications are based on the practical device parameters can be usages. The promising proposed device has been described in details and used in the references [2-7].

Nowadays, the on chip devices and techniques have been the good potentials for tissue applications [8-13], where Polacheck et al. [13] has reported recently the first demonstration of a microfluidic platform that captures the full physiological range of mass transport in 3-D tissue culture. The method used long microfluidic channels connected to both sides of a central micro-tissue chamber at different downstream positions, to control the mass transport distribution within the chamber. This simple platform can be applied to physiological and biological studies of 3D living tissue followed by pathological disease studies, such as cancer research and drug screening. The another form of tissue culture using a surface plasmon trapping and transportation within the modified optical add-drop filter has also been reported by Kamoldilok et al. [12], in which living cells/molecules can be trapped and storage within a PANDA ring circuit.

In this paper, we present the use of other forms of PANDA ring resonator for tissue culture, in which the PANDA ring device can be used to form the distributed sensing devices within a small scale chamber. A PANDA ring circuit is shown in Figure 1. The box base device consists of a cell unit and distributed sensors as shown in Figure 2, in which the tissue cells can be trapped and brought into the chamber by trapping probe or microfluidic channels [12,14], which can be securely trapped by optical capsules and moved along the PANDA ring circuits under the gradient forces [2], as shown in Figure 3. The travelling of light trapping probes within the PANDA ring circuit is as shown in Figure 4. The trapped tissue cells can be stored and cultured within the small scale chamber by the harvesting device called the molecular filter [14].

The input light (Gaussian pulse) is fed into the cell unit *via* the input port, in which the stable (resonant) output after circulation along the center ring is coupled, and formed the trapping probes by the nonlinear effects from the two side rings. The detected signals are obtained by the drop port, where part of light is travelling to the through port, in which the modulation of light can be applied *via* the add port. Moreover, the center ring can be the coated material (i.e. Au), in which the magnetic (or current) sensors can be applied for tissue culture monitoring.

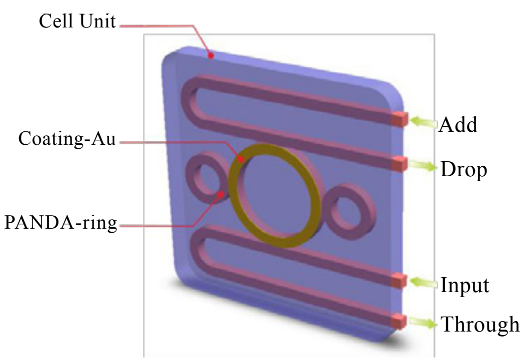

Figure 1: A proposed PANDA ring circuit for distributed sensors.

Figure 5 shows this two-dimensional plot and nicely demonstrates the phase conjugate signals (see highlighted regions), in which the

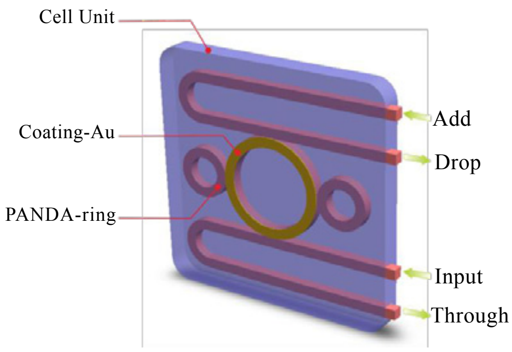

Figure 2: Distributed sensor system for tissue culture imaging and monitoring which can be formed on a chip.

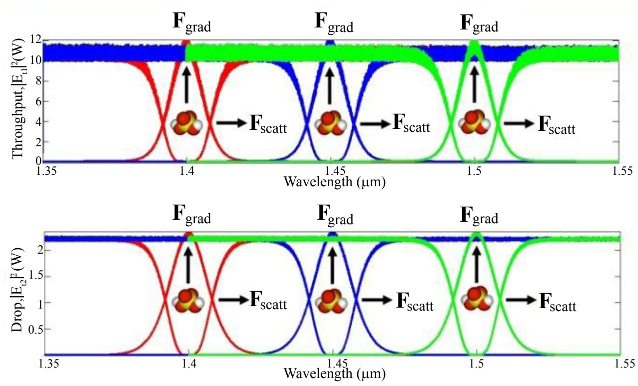

Figure 3: Trapped tissues by optical capsules in a PANDA ring circuit.

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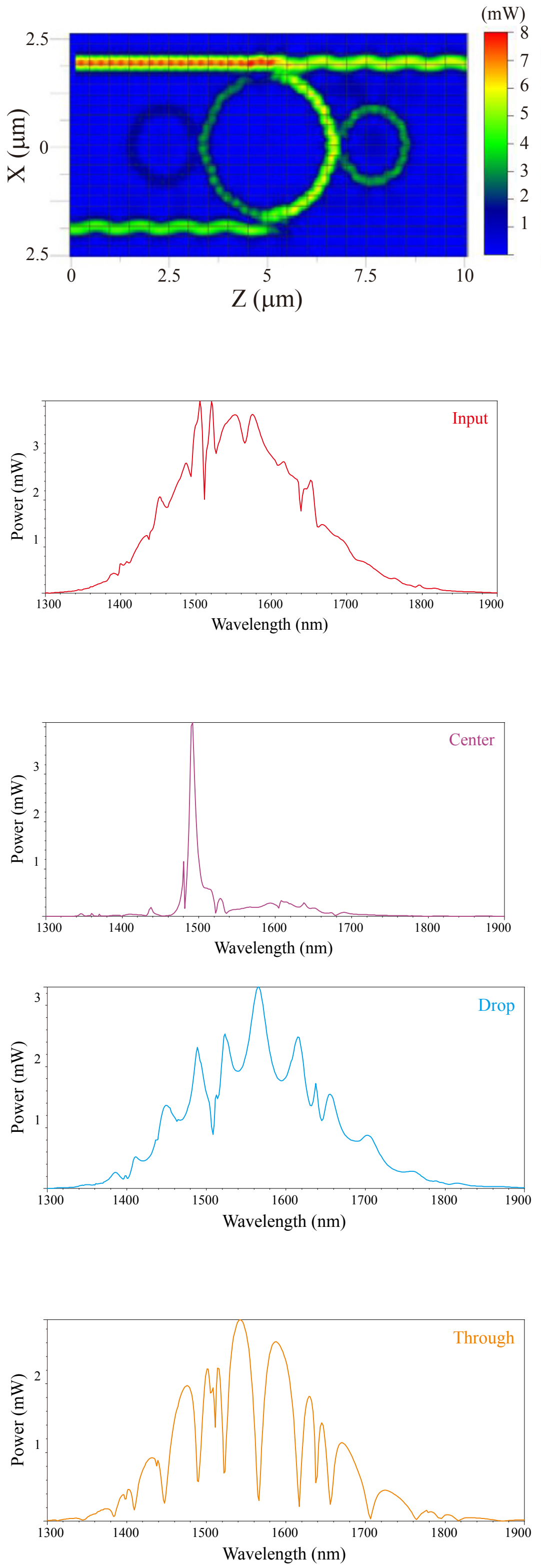

Figure 4: Gaussian input and light travelling in a PANDA ring circuit.

design structure of device which consists of a nonlinear microring resonator and two phase conjugate mirrors, as shown in Figure 1, which demonstrates that this device can be used to construct and reconstruct

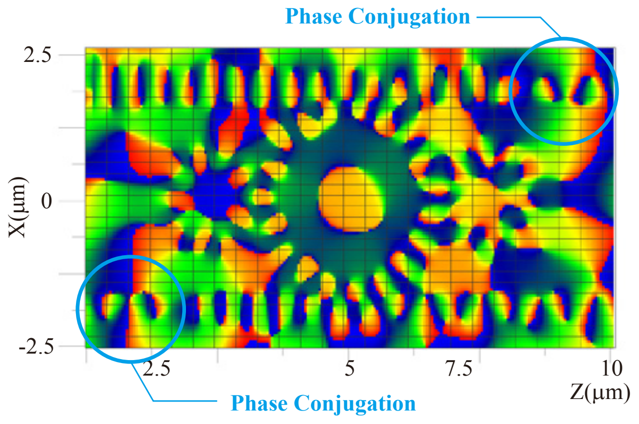

Figure 5: Simulation result of 3D imaging display using conjugate mirror formed by a PANDA ring circuit [6].

3D images for display applications, in which the object and reference beams can be configured by the through and drop ports of the modified add-drop filter. The interference signals of those two beams can be constructed and seen by the whispering gallery mode at the center ring, which is the real time image. In contrast, the reference interference signals can be detected by the add port output, which is required for the reconstruction process, similar to the conventional holographic technique.

In applications, the tissue cells distributed sensors can be formed by using the phase shifter values among the unit cells, where the shift in phase of the signals in Figure 4 can be used to distinguish the changes (i.e. sensors), where for instance, the temperature, pressure, flow rate sensors can be established. In Figure 5, the use of conjugate mirror concept can also be exploited by a PANDA ring circuit, in which the 3D WGMs can be formed and seen on the other side of a box by a thin film device for 3D images tissue cells monitoring. By using the small scale tissue culture box, tissue cells can be transported, stored and cultured within the small scale chamber, which can be monitored by the distributed sensors and 3D images using the distributed PANDA ring circuits. The shift in phase of each cells be measured the drop ports and characterized.

In conclusion, an on chip device using the distributed PANDA ring circuits is an interesting technique for tissue culture and monitoring devices. We have presented a novel device system that can be potentially used for tissue culture with sensors and 3D monitoring applications. More precisely, by using the nonlinear effects within a PANDA ring, a new type of a conjugate mirror can be formed and 3D display realized. The large area (volume) of 3D image device can be constructed by making a thin film flat panel, where each unit of conjugate mirror is a pixel on the flat panel screen. Therefore, the area of whole images can be covered with a relatively large number of pixels, where the large area of distributed sensors is also available.

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