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Research Article

# Drug Targeting Model of Composite Gold-Tourmaline for Cells Enhancing Applications

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## Abstract

The drug delivery and targeting method of gold tourmaline composite atoms generated by optical tweezers in a micro-optical device system is proposed. Gold atoms can be trapped and mixed into the tourmaline content, from which the composite gold tourmaline atoms can be formed using the optical tweezers, which can be delivered close to the desired target cells for cells healing and enhancing applications. In simulation, the optical tweezers are formed by whispering gallery (leaky) modes of light can be generated within a modified add-drop filter, which is known as a Panda ring resonator. It is a nonlinear micro optical device, from which the optical probes called optical tweezers can be generated and used for atom trapping, removing and transportation. In this paper, the optical tweezers are designed for gold tourmaline composite atom trapping, in which the trapped gold tourmaline atoms can be deposited (removed) on (from) the surface for cosmetics and cells enhancing treatment usages. The advantage of the proposed scheme is that the applied (removed) atoms to (from) the surface treatments by the designed trapping and storage device, where the device controlled switching is the key function. In application, the composite trapped gold-tourmaline atoms can be stored with the storage device. In addition, the removal trapped gold-tourmaline atoms can be removed from the treatment surface, from which the used gold atoms can be possible extracted and reused. The cells enhancing and healing applications using the tourmaline properties such as magnetic and far infrared are also plausible.

**Keywords:** Drug delivery; Cells enhancement; Cells healing; Bio-sensors diagnosis; Cosmetics; Tissue engineering

## Introduction

Optical microring resonator has been the interesting device for nano-communication and network for high speed, and compact devices for large-scale platform [1-5]. One of the popularly used devices is an optical add-drop filter, which consists of one input port, one microring resonator, and two output ports. Generally, a microring resonator serves as a selector for optical carriers and wavelengths. These three-port devices function as switches to route optical signals to different output ports, allowing further integration of various devices on the same platform. Currently, an optical add-drop filter device can be made to form the other usage, which has shown the convincing challenges for particle or molecule electronics, especially, after the practical trapping particle work has been strongly confirmed by Cai and Poon [6-9], where particle or molecule could be trapped and transported within the add-drop optical filter, from which the concrete concept of theoretical work has been confirmed [10], where various applications have been investigated and reported [11, 12]. Moreover, several researchers have also shown that the modified add-drop optical filter called a Panda ring resonator has more benefits than the ordinary add-drop filter [13-17], in which the two nonlinear side rings of the optical add-drop device are made from the nonlinear material types that can produce may aspects of applications, for instance, high channel capacity, fast switching time and wide sensing range of applications etc. In fabrication, the used nonlinear materials can be the grapheme material, AlGaAs/InP and others, which can be useful for many aspects of applications.

Gold nano-particle is recognized as an excellent candidate for nano-medicine applications, especially, for cancerous cells treatment, cells enhancement and treatment effect, where there were many theoretical and practical works reported [18-22], where the key concept of such technology is to use a single gold atom for drug delivery applications. Such a technique can be used and performed successfully by incorporating the optical trapping tools (tweezers), where the specific tweezer wavelengths and powers can penetrate without harm into the target cells and treatment surrounded areas, in which the treatment can be securely performed. Regarding to the successful gold atom treatment, therefore, there is the searching of new form of material that can be useful for medical treatment, diagnosis and therapy, where recently gemstones have become the interesting materials that can be considered to add into the nano-particle contents. In practice, the nano-particle based on material size is not much increased and changed from the nano-scale size. Naturally, one of the interesting gemstone families known as tourmaline has been found in various places [20, 23-25], where the far infrared and magnetic properties are the key treatments of this material.

Tourmaline has been widely used in cosmetics business recently but there is no evidence of safety and toxic concerns. Tourmaline powder can be mixed with the gold nano-particles and applied for cells healing and enhancing applications [26-28], for instance, magnetic and aura therapies. The treatment of such material can be in the form or mixture powder for cosmetics usage. However, there is no evidence of toxic of short period surface treatment, which may be the usage limitation. There are many types of tourmaline in nature, from which the black tourmaline is one of them that can give the interesting feature applications, which can be useful for the cells enhancement, healing and therapy, which can be categorized as followings, (i) healing therapies, (ii) physical healing energy, (iii) emotional healing energy, (iii) Chakra healing and balancing energy, (iv) spiritual energy, (v) color energy, (vi) meditation, angelic realm, (vii) divination, where more details can be found in the given references. Apart from the tourmaline surface treatment for cosmetics usage, there is another interesting aspect that the use of tourmaline characteristics may be realized and useful for deep skin layer cells enhancement, healing and therapy by using the drug delivery method. By using this method, the tourmaline powder can be mixed by the solid material atom, for instance, gold atom and delivered close to the target cells. The required target cells can be enhanced by the gold tourmaline composite atom, from which the target cells can be excited and exchanged in energy between the tourmaline and cells, which is useful for cells enhancing and healing. However, this is the proposed work that there is no evidence of tourmaline toxic occurred in the surface treatment for cosmetics usage. Thus, the safety and toxic concerns must be the serious problems of the deep skin layer, which will be the big issue of research and investigation within this decade.

In this paper, the optical trapping tools (tweezers) generation using whispering gallery (leaky) modes of light within a modified add-drop filter is modeled and simulated, where in addition the trapping force and drug delivery details are reviewed and presented. In application, the potential of using the proposed device for cells enhancing and healing using trapped composite gold-tourmaline atoms is also proposed and discussed. The advantages are the gold and tourmaline properties that can give more benefits for medical diagnosis and therapy, for instance, the electrical, magnetic and infrared properties, which can be useful for medical diagnosis and therapy. The use of proposed device for gold nano-particle with/without tourmaline material and safety issue is discussed.

## The Model

To explain the technique of nano-particle trapping using optical technique, the optical trapping tool generation using laser propagation in a micro-optical device with suitable wavelength is recommended. Particle (WGMs) of light within the microring resonator can be generated by light propagation within a modified add-drop optical filter, from which the WGM outputs can be detected at each center ring within system in either in or out of the device surface, which have shown the advantage for atom trapping applications. Moreover, the leaky modes of light can also be used to form the optical tweezers for high density drug delivery usage, which has been the promising technique of drug trapping and delivery in this decade, more description can be found in references [31, 32]. Principally, the basic tool of drug trapping is the optical tweezer that can be formed by light pulse, where in this work it can be generated by using the device in Fig. 1(a), where the required output is the WGM probe that can be generated and described by the following equations.

$$E_{in} = E_0 \exp\left[\left(\frac{z}{2L_D}\right) - j\omega t\right] \tag{1}$$

$$E_1 = j\left(\frac{AE_{i1} + BE_{i2}}{CD}\right) \tag{2}$$

$$E_2 = \left(\frac{x_2y_2 - x_2^2y_2^2P_R - x_2^2z_2^2P_R}{1 - x_2y_2P_R}\right)E_1 \tag{3}$$

$$E_4 = \left(\frac{x_4y_4 - x_4^2y_4^2P_L - x_4^2z_4^2P_L}{1 - x_4y_4P_L}\right)E_3 \tag{4}$$

$$E_3 = \left[\frac{\left(x_2x_3y_2y_3P_{L4} - x_2^2x_3y_2^2y_3P_{L4}P_R - x_2^2x_3y_3z_2^2P_{L4}P_R\right)E_1 + j\left(x_3z_3P_{L8} - x_2x_3y_2z_3P_{L8}P_R\right)E_{i2}}{1 - x_2y_2P_R}\right] \tag{5}$$

where

$$A = x_1z_1P_{L8} - x_1x_2y_2z_1P_{L8}P_R - x_1x_4y_4z_1P_{L8}P_L + x_1x_2x_4y_2y_4z_1P_{L8}P_RP_L$$

$$B = x_1x_3x_4y_1y_4z_3P_{L4}P_{L8} - x_1x_2x_3x_4y_1y_2y_4z_3P_{L4}P_{L8}P_R - x_1x_3x_4^2y_1y_4^2z_3P_{L4}P_{L8}P_L + x_1x_2x_3x_4^2y_1y_2y_4^2 \times z_3P_{L4}P_{L8}P_RP_L - x_1x_3x_4^2y_1z_3z_4^2P_{L4}P_{L8}P_L + x_1x_2x_3x_4^2y_1y_2z_3z_4^2P_{L4}P_{L8}P_RP_L$$

$$C = x_1x_2x_3x_4y_1y_2y_3y_4P_{L4}^2 - x_1x_2^2x_3x_4y_1y_2^2y_3y_4P_{L4}^2P_R - x_1x_2^2x_3x_4y_1y_3y_4z_2^2P_{L4}^2P_R - x_1x_2x_3x_4^2y_1y_2y_3y_4^2 \times P_{L4}^2P_L + x_1x_2^2x_3x_4^2y_1y_2^2y_3y_4^2P_{L4}^2P_RP_L + x_1x_2^2x_3x_4^2y_1y_3y_4^2z_2^2P_{L4}^2P_RP_L - x_1x_2x_3x_4^2y_1y_2y_3z_4^2P_{L4}^2P_L + x_1x_2^2x_3x_4^2y_1y_2^2y_3z_4^2P_{L4}^2P_RP_L + x_1x_2^2x_3x_4^2y_1y_3z_2^2z_4^2P_{L4}^2P_RP_L$$

$$D = 1 - x_2y_2P_R - x_4y_4P_L + x_2x_4y_2y_4P_RP_L$$

$x_i = \sqrt{1-\gamma_i}$, $y_i = \sqrt{1-\kappa_i}$ and $z_i = \sqrt{\kappa_i}$, where $i$=1, 2, 3 and 4

$$P_R = \exp\left(-\frac{\alpha}{2}L_R - jk_nL_R\right),$$

$$P_L = \exp\left(-\frac{\alpha}{2}L_L - jk_nL_L\right)$$

where $L_R=2\pi R_R$, $L_L=2\pi R_L$ and $k_n=2\pi/\lambda$

$$P_{Li} = \exp\left(-\frac{\alpha}{i}L_D - 2jk_n\frac{L_D}{i}\right)$$

From Fig. 1, the input fields propagate within the PANDA ring are substituted by a group of equations, where $E_1$, $E_2$, $E_3$ and $E_4$ are the electric fields, $\gamma_1$, $\gamma_2$, $\gamma_3$ and $\gamma_4$ are the fractional coupling losses, $\kappa_1$, $\kappa_2$, $\kappa_3$ and $\kappa_4$ are the coupling coefficients, $\alpha$ is an attenuation coefficient, $k_n=2\pi/\lambda$ is the wave propagation number in vacuum, $L=2\pi R$ is the center ring propagation distance, $L_{R \text{ or } L}=2\pi R_{R \text{ or } L}$ is the nanoring propagation distance, where $R$ and $L$ denote as right and left nanoring radii, $j = \sqrt{-1}$ is the imaginary part of complex number. The nonlinear refractive index ($n$) of the substances in the system is defined by

$$n = n_0 + n_2I = n_0 + n_2\left(\frac{P}{A_{eff}}\right) \tag{6}$$

where $n_0$, $n_2$ are the linear and nonlinear refractive indices, where $I$ and $P$ represent the optical intensity and optical power respectively. Where $A_{eff}$ is the effective mode core area [33], which is ranged between

0.10 μm² and 0.50 μm². From Equations (2)-(5), the rearrangement of WGM in the Equation (2) is used to obtain the whispering gallery mode output.

This proposed device and system are designed and simulated by using the practical parameter values, which means that the realistic fabrication and test can be produced. However, the cost of fabrication of a prototype is very high, therefore, this proposed work can be done and achieved by simulation and manipulation which is based on practical device parameter values. By using Equations (1)-(5), the main parameters are given by the above details (insets). The whispering gallery mode (trapping probe) of the PANDA ring is obtained by using Equation (5), which can be used as an optical tweezer (optical probe), where the tweezer witching up or down can be controlled for atom injecting and removing usages. In application, the certain skin layer penetration dept and target cells can be designed by the suitable trapping force and atom size, where the required switching wavelength and power can be given to work with harmless to the target cells environments. However, this is a low injection power and electrical current that cannot be harm to the good cells. Alternatively, cells can be excited by the infrared light, where the required heat (energy) level can be controlled and used for cells enhancement and therapy. Moreover, the use of nano-particle composites, for instance, gold-tourmaline composite particles, especially, the black tourmaline as previous mentioned can be plausible for aura diagnostics and therapy. The trapping and switching model is as shown in Fig. 1(b) and 1(c), which will be described in the following section.

## Simulation

Currently, all forms of light travelling within a Panda ring resonator can be described in various forms, for instance (i) wave propagation by ray tracing, (ii) particle aspect by Schrodinger equation and (iii) the leaky modes and whispering gallery modes (WGMs) [34]. In Fig. 1, light from a semiconductor laser source with power 0.5 W is input into the PANDA ring input port then it circulates within the device. The whispering gallery modes of light within the device can be generated by controlling the suitable conditions (parameters), where finally the required optical trapping probes in the forms of surface plasmon pulses can be obtained. The other device parameters are chosen and simulated for wider investigations. In Fig. 1(c), the optical switching of WGM probes can be formed and controlled via the add port input signals,

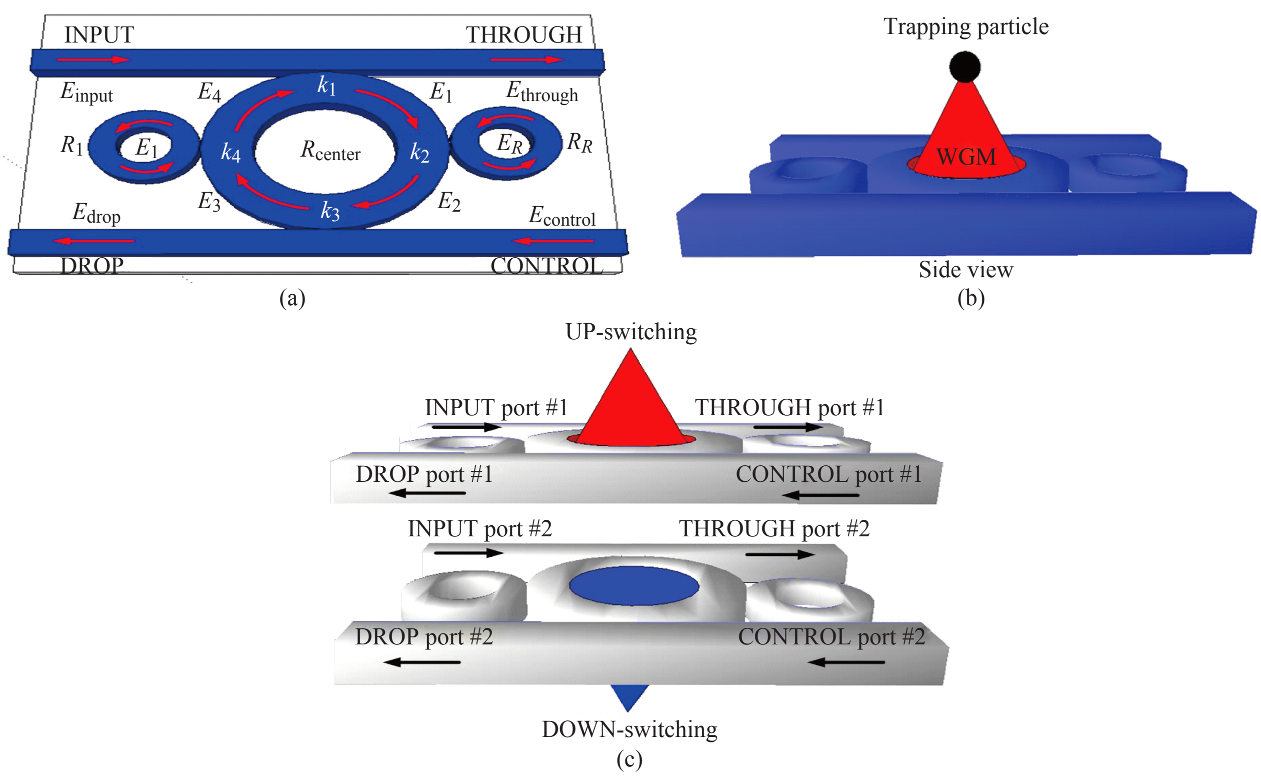


**Fig. 1** A schematic of nano-particle trapping and injection device, where (a) A PANDA ring resonator, (b) Trapped particle by WGM probe, (c) Tweezer switching direction model.

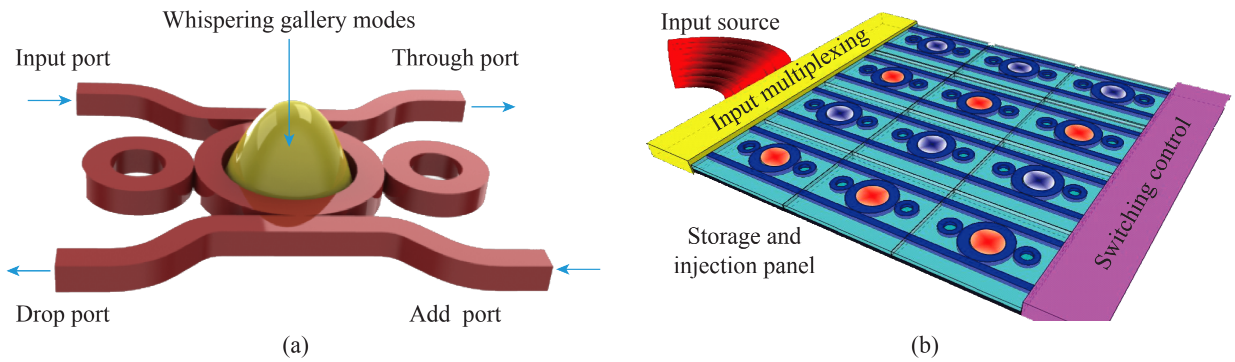


**Fig. 2** Model of nano-particle trapping and storage with a tissue buffer, where (a) A single device model, (b) A device array model.

where the superposition of signals can be arranged to obtain the required switching probes and directions. In the experimental simulation, the used system is as shown in Fig. 2, where the model of nano-particle trapping and storage panel is schematically detailed. The array of Panda ring device can be produced for large scale trapping probes, where the large scale treatments can be realized. The simulation programs are the commercial MATLAB and Opti-wave software. All parameters are chosen based on the practical device parameters. The input wavelength source into the system is 1.55 μm, which is input into the input port of the AlGaAs/InP ring material. The center ring radius is 2.0 μm, the right and left ring radii are 1.05 μm, the coupling constants(κ) are $\kappa_1 = \kappa_2 = \kappa_3 = \kappa_4 = 0.5$, the linear and nonlinear refractive indices are $n_0 = 3.9476$ and $n_2 = 1.7\times10^{-13}$ $cm^2 \cdot W^{-1}$, respectively [33], the waveguide loss(α) is 0.1 $dB \cdot m^{-1}$ and $\gamma = 0.01$. In Fig. 2(b), the red color outputs are the WGM outputs that direct outward (switching up) from of the device surface, where the blue color ones are the outputs that direct inward (switching down) into the device, which can be used to form the required switching directions and used for injecting and removing atoms. The composite atoms can be stored within the panel, where the injecting and removing atoms can be applied by using the switching control via the add port input control. The nano-particle trapping panel (thin film) is as shown in Fig. 2, where the tissue buffer is needed the specific design to protect the unwanted tissue treatments. Typically, a single device can be a centimeter scale dimension. However, the panel dimension can be ranged from 1 centimeter to 10 centimeter because the large area device is needed for more area of applications. In the simulation, it was found that the WGMs and leaky modes of light within the Panda ring can be generated and controlled by using the appropriated simulation parameters, which means that the use for practical may be plausible and realized. More details will be given in the following section.

## Technical Concept

In this proposal, we believe that the drug targeting of the composite gold-tourmaline atom can be performed based on the following reasons, (i) gold particle trapping is well established, (ii) particle trapping technique is experimentally confirmed, (iii) the reasonable trapping force is confirmed, and (iv) the natural tourmaline is existed. Regarding to the previous section, the required leaky or WGM modes can be controlled to form the required tweezer switching (up or down switching) probes, where the trapped composite gold tourmaline atoms can be obtained. In operation, the trapped atoms can be deposited (injected) into the required positions. By using the proposed panel, the composite gold tourmaline atoms can be trapped, stored within the panel before the cosmetics treatment being used, which can be suitable for both flat and rough surfaces, which is shown in Fig. 3(a), where the tweezer probes can be generated by the proposed device in the forms of WGM and leaky mode light probes, which is suitable for large area application. In addition, the removed gold atoms can be operated from the embedded positions by the opposite switching direction, from which the gold atoms can be extracted from the tourmaline mixture.

The use of this technique can be categorized into two forms, where firstly, the injection method, secondly, the removal method, where both methods are commonly needed the safety operation. The trapping force is consisted of gradient force ($F_{Grad}$), scattering force ($F_{Scatt}$), friction force ($F_{Fric}$) and viscosity force ($F_{Vis}$) as shown in Fig. 3(b) [35], where the scattering force is generated by the conservation of momentum,

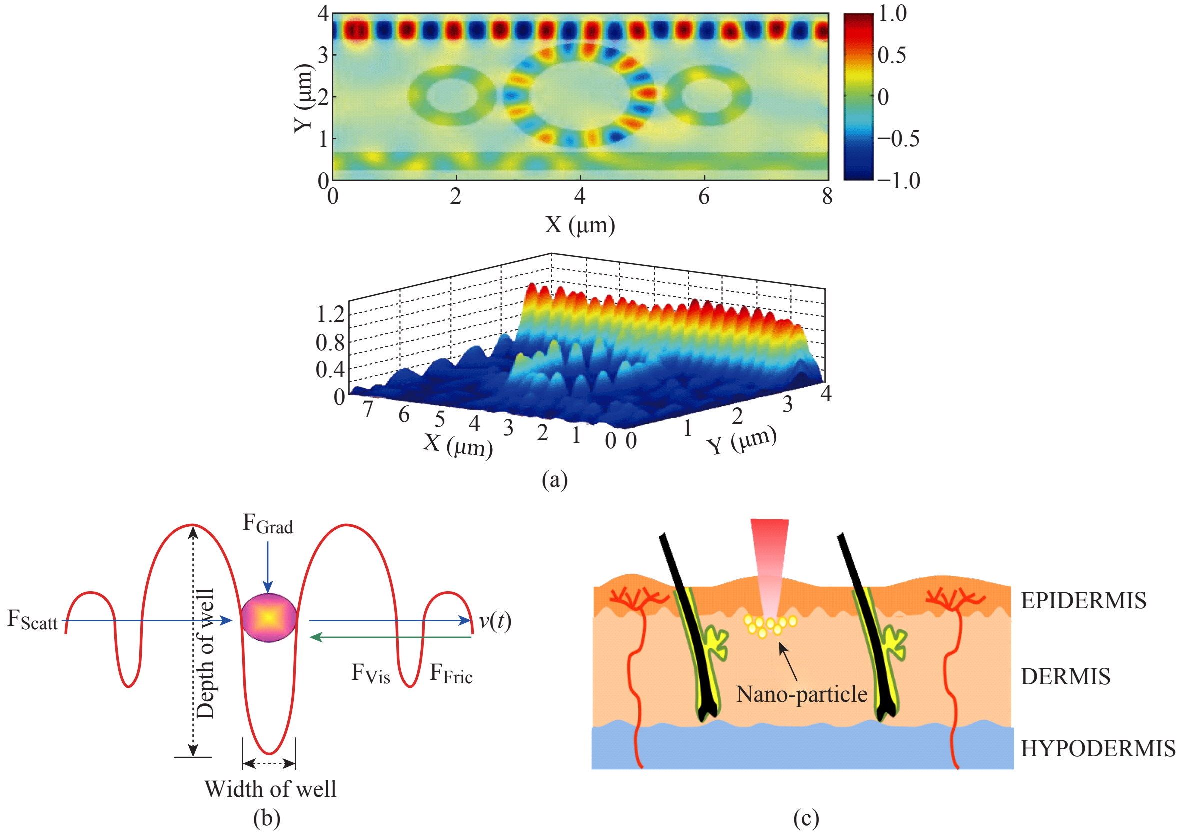


**Fig. 3** Atom trapping and injecting structures, where (a) The optical probes (tweezers) in three dimensions X(μm), Y(μm) and Z(μm) [34], (b) The trapping tool and width model, (c) The embedded atoms into the skin layer.

the gradient force is the generated by light pulse potential energy in the form of Gaussian pulse, where the two components of optical tweezer forces are generated by the gradient of electric potentials, which they are in the forms of potential well (valley signal) and surface plasmon (peak signal). $V(t)$ is the trapped atom velocity in the resultant force direction. The combination of those four vector forces is the resultant force, which is normally within the range of pico to nano Newton [36-38], which is large enough to trap the nano-scale particle, for instance, gold, silver or bio-cells. In this proposed device, the required atoms can be trapped and dragged by the WGM probe. The atom injection into the deep skin layer is as shown in Fig. 3(c), where the combination of forces is the key role of this phenomenon. The trapping and switching atom concepts are as shown in Fig. 1(a) and 1(b). The stable tweezer outputs are required with certain trapping force values before the application being used, which means that the defects of the device is allowed if the output tweezer stability is maintained. This model is suitable for nano size particle. However, the bigger size can be employed by the bigger trapping force and tweezer size. Number of trapped atoms can be increased by the increasing in tweezer width and power, which means that the resultant force is increased due to the increasing in optical power, where finally, well depth and width of the trapping probe can be designed and suitable used, however, the safety issue is needed to be taken care.

## Applications

### Cosmetics Treatments

A thin film array panel using multi-optical trapping probe system is designed and modeled using the well-established commercial software (Opti-wave), where the practical device material, scale and parameters are manipulated and results shown. Gold nano-particles have been the promising potential elements of using for therapeutic and cells enhancements, especially, for cancerous cells treatment and cosmetics. The use of gold nano-particle is combined with the other minerals such as gemstones have become the interesting aspect of applications. Regarding to the nano-scale technology regime, the combination between gemstones and gold (silver) nano-particles can be formed, where the composite gold nano-particles by gemstones can keep the dimension of them being in the nano-scale range, which can be used similarly to the original drug delivery concept ones. However, the new mechanism, treatment method and safety issue are become the important things for investigations.

Tourmaline is recognized as the innert material though the complex mineral in nature, which has the electical, i.e. piezoelectric property, which is suiatble for cosmetics applications due to the infrared light dsitribution property [39]. Furthermore, there is no published research showing tourmaline has any proven effect on skin whatsoever, especially, for surface treatment.Tourmaline can generate an electrical charge when it is in the pressure environment, from which it can be used for pressure sensors (pressure gauges). Tourmaline also has the pyroelectric property, where the electrical charge is changed during a temperature change. Although, this is the modeling paper based on the previous system design and results, in which the use of composite gold tourmaline in the proposed model can be done similarly to the pure Au and Ag particle usages, where the gold and tourmaline properties can provide more benefits in electrical, magnetic and thermal properties, which can give benefits for the applications such as cancer cells killer and acne treatments [40], while the magnetic property of particle has also been used in the magnetic sensors and therapy using the nano-scale device [29, 41]. In addition, the far infrared treatment using the tourmaline, especially, the black tourmaline has shown the promising application, especially, the aura therapy.

## Cells Enhancing

Cells enhancing in this work is concentrated on the facial cells treatment, which can be enhanced by using the composite gold tourmaline atom properties, where the successful applications have been realized by the surface treatments in cosmetics use. Regarding to this proposal, the trapping technology, the shallow skin layer treatment using the composite gold-tourmaline is proposed and may be possible. In Fig. 1, the optical trapping probes are generated using the nonlinear microring resonator known as a PANDA ring resonator, which can be used to trap and transported atoms into the skin layers. The used material is AlGaAs/InP that can be used to form the trapped atom/molecule storage system, in which the net trapping force is produced by the gradient and scattering force of the trapping probe that generated by the optical tweezer in the scale of pico (nano) scale force [37-39]. The WGM output wavelength is ranged within the infrared spectrum region, which is claimed as the harmless light power to the trapping atom and environmental cells [27, 42]. The atom delivery (injection) and removal to/from the target atoms can be operated by using the WGM switching control. The large area of trapping probes can also be formed and used as an injection, storage and removal tools for deep skin or surface treatment usages. After trapping, the designed particles can be injected, removed, excited, embedded, enhanced and releasing within the target cells positions. The required cells treatment and enhancement can be provided and realized. Safety issue of using such content for facial surface treatment is very important and needed to be clarified in this works, where apparently, the use of purely gold nano-particle and no evidence of toxic generation in any form. The safety issue of such a proposed scheme, especially, the nano-particle and gemstone toxics will be discussed in the next section.

The form of resultant force is generated by a surface plasmon pulse in either peak or valley forms. The traveling distance of force can be desired and improved. In practice, the aura shading area and wavelength can be seen by using the specific detector (camera), in which the specified filter is required to detect the far infrared wavelength output, which is ranged between 6-14 μm [27, 39]. The aura shading area can be used in medical diagnosis and investigation, where the specific analysis and therapy can be assigned. For instance, the use of medical diagnostics for some specific cases, where the penetration depth of the delivery atom can be controlled to reach the designed embedded location (position) [36], where the shallow skin layer between 100-200 μm could be possible. While the removal of atom can also be done by using the similar technique but in this case the embedded atoms are trapped and removed from the desired positions by using the trapping probe switching control. However, the penetration depth range can be improved by the suitable WGM power and width, which will be the key issue of the interesting research and investigation. By using this proposed panel, the embedded and removed atoms can be desired, thus, the embedded duration time can be considered for security usage [43, 44]. For instance, the use of composite gold-tourmaline can be realized for shallow skin layer cosmetics, where in addition, the use of aura diagnostics and therapy can also be plausible [27, 28]. The use of such proposed device panel for other applications such as magnetic net and therapy, cells enhancements and cancerous cells treatments are also available.

## Conclusion

We have shown that the drug delivery method incorporating the THz technology can be applied for cosmetics treatments and medical applications, where in addition the THz wavelength output is not harmed to cells and the surrounded environment. We have also proposed that the technique of facial cells treatment and enhancement using in either pure gold or composite gold-tourmaline is very interesting, where the benefit of far infrared, positive ion and magnetic property of the composite gold-tourmaline have become the challenged potential benefits. Generally, the other gemstones can also be applied by the same technique but the safety issue is needed to be clarified and tested before being realized and used. The advantages of the proposed technique are used to (i) trap, store and remove composite gold-tourmaline atoms, (ii) trap gold atoms and mix with tourmaline before injection (delivery), apply for cells enhancing and healing usages, and (iii) extract gold atoms from tourmaline. By using this technique, the trapping probe was firstly generated by using the well-known optical technique and software, where the nano-scale force of optical probe could be generated and used to trap the required gold particles, which can be mixed to tourmaline and injected closely to the target cells, where in this case the penetration depth of injection atom can be controlled by light source powering and focusing probes. Alternatively, the opposite switching of trapping tool could be controlled and used for atom removal requirements. The advantage of this device is that atoms can be trapped, injected to the certain dept and removed from the deposited position without any harm to the surrounded cells, i.e. a nondestructive (NDT) method. The benefit of far infrared treatment concept using tourmaline property is also available, which can be treated as the aura diagnosis and therapy.

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## Disclosure

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