

Band-Pass Filter for Fluorescein Interference Rejection Using Microscope with Surgical Robot Applications

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Abstract—Recently, the diagnosis technique is rapidly growth. The diagnosis method has CT, MRI, surgical navigator, and surgical microscopy. The surgical robot is connected to diagnosis system. However, the diagnosis system is impossible to division of tumor and normal tissue due to similar formation and color. The fluorescein dying method can be diagnosis for division between tumor and normal tissue due to fluorescein color staining. Therefore, the tumor removal surgery is used for fluorescein dying diagnosis using surgical robot. However, fluorescein dying is generated interference. Therefore, the fluorescein diagnosis resolution is not good due to auto-fluorescein. Thus, the interference must be rejection through the filter usage. In this paper, the new optical filter for interference suppression using fluorescein diagnosis method in the surgical robot. The designed filter is used for coating layer method.

Index Terms—surgical robot, filter, fluorescein, interference, microscope

I. INTRODUCTION

Newly, the observation and diagnosis techniques are rapidly growth and the fluorescein microscope with surgical robot is essential component in the cancer and brain cancer surgery [1]. Because, the surgical robot is not necessary to laparotomy and the surgical robot is possible to minilaparotomy. Therefore, the surgical robot is used for neurosurgery, otorhinolaryngology, orthopedics, ophthalmology, and obstetrics & gynecology [2].

In the surgical robot, the surgical robot is connected to fluorescein performance, which has diagnosis for tumor, implementation, inflammation, polyp, and disease through the fluorescein dye [2].

The fluorescein is injected to tumor after the tumor is exposed the laser for fluorescein generation at surgical robot. Then, the wavelength of laser source is 785 nm and the fluorescein wavelength is 815 nm to 830 nm, respectively [3].

The fluorescein is generated interference due to auto-fluorescein phenomenon. The interference should be suppression by filtering in the surgical robot. The filtering wavelength have to above 815 nm to 872 nm nm. In this paper, the optical filter with interference rejection using coating layer is presented. The designed filter is good performance.

II. ANALYSIS OF THE SURGICAL TECHNIQUE

A. Surgical Robot

The surgical robot is developed on 1860 to 2010, which is developed open surgery to flexible access surgery as shown in Fig. 1.



Figure 1. Alteration of surgical robot technique.

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The surgical robot is composed of endoscope, biplanar fluoroscope, navigation, master slave, macro-microrobot, and instruments as shown in Fig. 2.

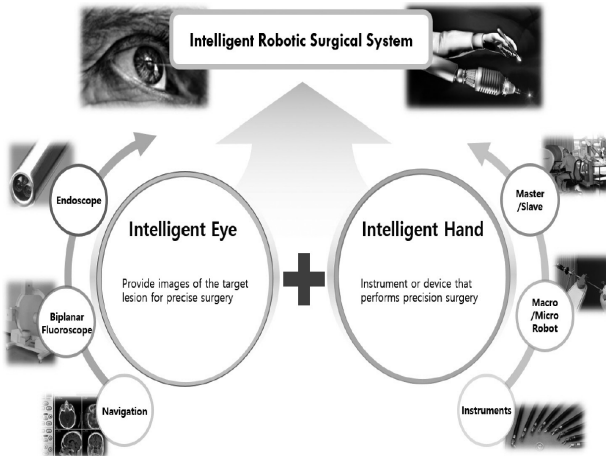


Figure 2. Performance of surgical robot.

In the Fig. 3, the surgical robot design technique is divided two types, which has intelligent eyes and intelligent hand, the surgical robot is divided two types, which has image-guide surgical robot, and endoscope guided surgical robot [4], [5].

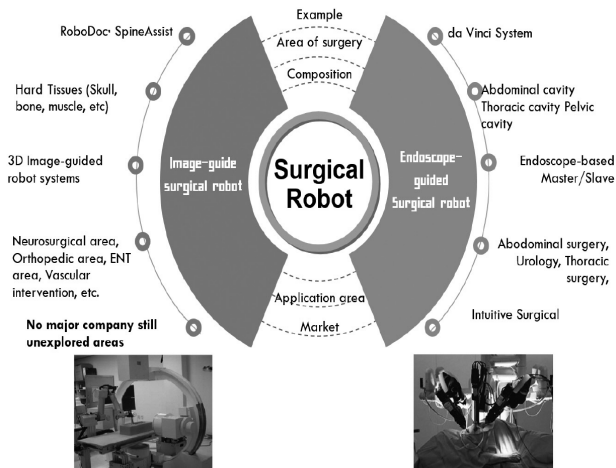


Figure 3. Division of surgical robot.

The advantage of surgical robot is laparoscopic by minimal resection, low side effect, and high-speed recovery.

B. Fluorescein Dying

In general, the fluorescein substance is commonly used for indocyanine green (ICG) which has purpose of diagnosis with fluorescein in the tumor or blood as shown in Fig. 4 [6].

Fig. 5 shows the ICG wavelength. The ICG has typical wavelength of 800 nm and green color at near infrared wavelength [7].

To generate the ICG fluorescein, the ICG fluorescein occur to chemical response between fluorescein protein and tissue. The chemical response of fluorescein protein is shown in Fig. 6 [8], [9].

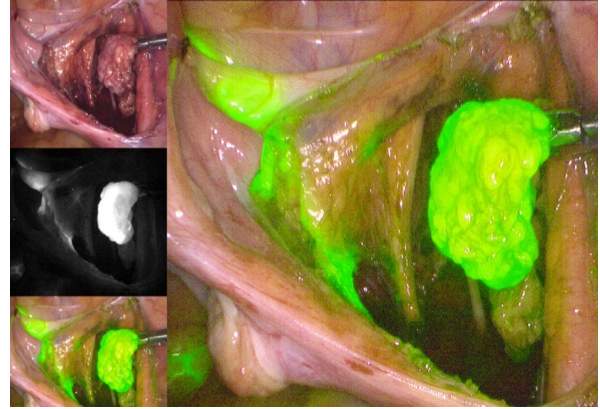


Figure 4. Diagnosis of the tissue using indocyanine green.

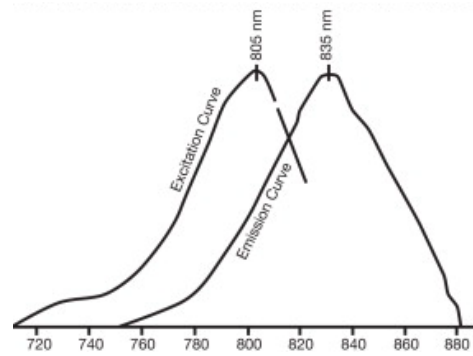


Figure 5. Wavelength of the indocyanine green.

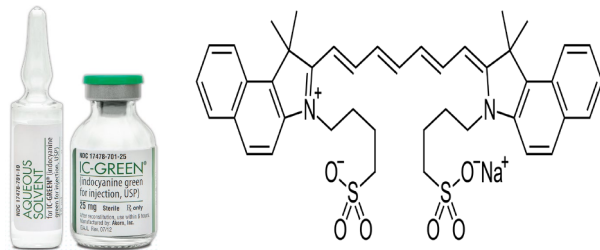


Figure 6. Chemical response of ICG fluorescein protein.

The ICG fluorescein response is generated after 3 to 5 minute when the ICG substance inject to vein. Then, the blood and tumor is divided two colors and the blood is changed the green color to red color.

III. EXPERIMENT OF THE COLOR CAMERA PERFORMANCE WITH FILTER

The filter is used for camera which is photograph the tissues and fluorescein image and it is composed of CMOS performance as shown in Fig. 7.



Figure 7. Configuration of the CMOS camera and filter.

If the laser is exposed the tissue, the tissue is emitted fluorescein. Also, the fluorescein will be possible to injection in the CMOS camera by the filtering such as Fig. 8 [10].

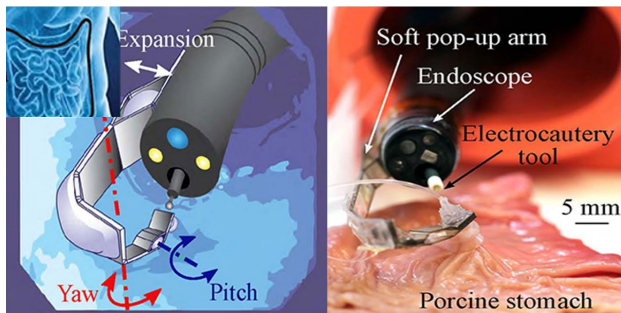


Figure 8. Fluorescein endoscope with surgical robot.

IV. MANUFACTURING AND TEST OF THE FILTER

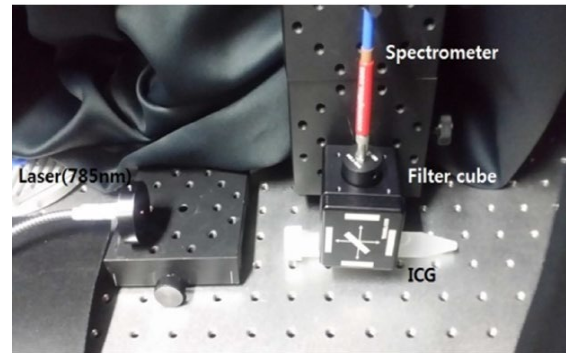
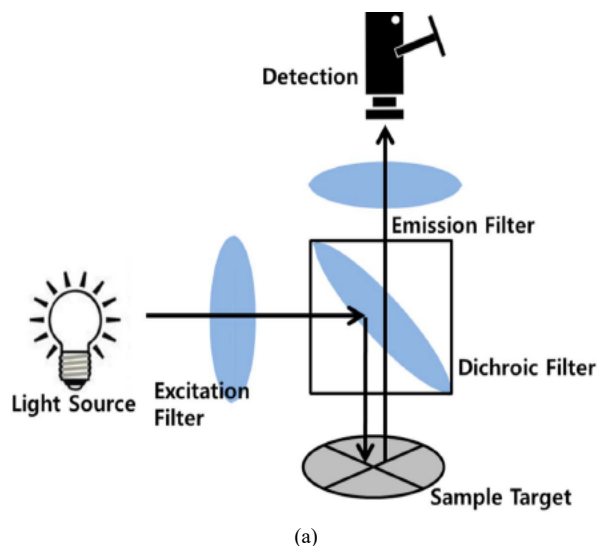
The manufacturing of the optical filter is exhibited on Fig. 9. From the figure, the diameter and thickness of the filter are 25 mm and 1.032 mm and the band pass wavelength range is 815 nm to 872 nm.



Figure 9. Manufacturing of the optical filter.

Fig. 10 shows the configuration of the test environment for optical filter. From the figure, the emission for fluorescein was detected by photo-coupler.

The wavelength of fluorescein is 815 nm to 830 nm as shown Fig. 11. From the figure, the photo-coupler was generated fluorescein wavelength with laser wavelength. Then, the laser wavelength is included interference. Therefore, the interference has to rejection through the filter.



(b)

Figure 10. Configuration of the filter test board (a) structure (b) test set.

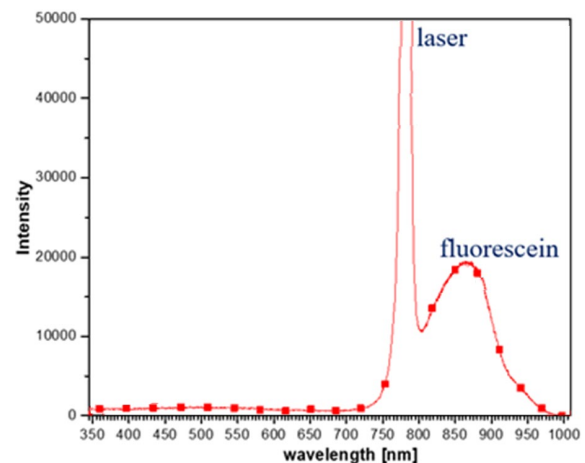


Figure 11. Fluorescein with interference.

The test result for the manufacturing of an optical filter is shown in Fig. 11. From the figure, the pass band and reflection band are 95 % and 5 % at filtering wavelength of 815 nm to 872 nm, respectively. The optical density is within 1.02.

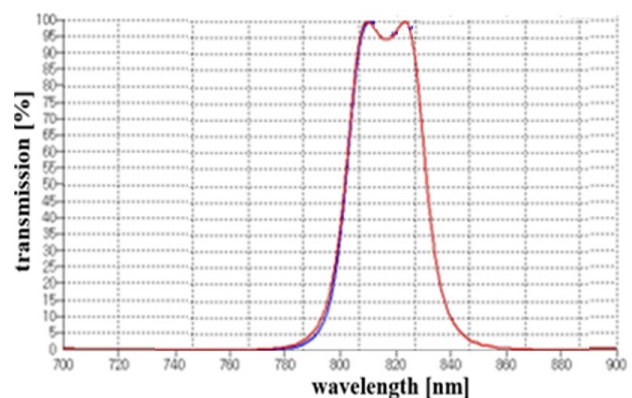


Figure 12. Test result of an optical filter.

V. CONCLUSION

In general, the microscope is used for fluorescein substance for tissue diagnosis and it is generated the light of fluorescein with wavelength range of 815 nm to 830 nm in the surgical robot. The general surgical microscope is used for beam splitter due to interference rejection way. However; the surgical microscope has low quality.

resolution and high attenuation of the fluorescein image in the surgical robot. Therefore, the imaging resolution is unclear enough to diagnosis and the interference noise can be rejected surgical microscope through the filter. In this paper, the interference suppression for fabrication of an optical filter using surgical fluorescein image guided microscope is manufactured.

The pass band wavelength and reflection wavelength of the manufactured an optical filter are 95 % and 5 % at wavelength of 815 nm to 830 nm and the optical density is within 1.02. The characteristic and merit of a manufactured an optical filter is interference wavelength rejection and high efficiency and it will be applied to surgical fluorescein image guided microscope in the surgical robot for tumor diagnosis.

CONFLICT OF INTEREST

All other authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

Ki-Cheol Yoon, Tae-Hyeon Kim, and Taishin Chung designed optical devices and filter and the Euji Kim supported clinical data. In addition, Hyun-Woo Jeong, Seung Hoon Lee, and Kwang Gi Kim advice the chemical medicine information.

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