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Optimal infrared wave length for healing pigmentations

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Abstract– Effective Infrared lasers wavelength for medical applications especially for removal of hair and some pigmented lesions are investigated. The lasers with the wavelength of about 700nm are selected considering the absorption coefficients of water, oxyhemoglobin, oxyhemoglobin and melanin. We used about 100mW semiconductor lasers, which are enough output power to examine the laser effect on the melanin. In this research, a hair is selected for melanin sample. The purpose of this paper is to consider a dependence of wavelength on a temperature rise in a melanin.

1. Introduction

The infrared laser is easy selectively absorbed to the melanin which exists under the skin, then, it is effective to cure of pigmented lesions. Since the hair also contains melanin, it is possible to apply to the laser hair removal, too. But former laser equipment (Table 1) are huge (ex. ; W:510, D:810, H:109mm, 136kg), expensive and moreover the technical knowledge is necessary to use it. On the other hand, as for the goods which are sold for the individual use, the wavelength, the output power, the irradiation wavelength and so on are ambiguous. Lasers with various wavelengths are used to the same cure and the optimal wavelength doesn't become clear.

In this paper, the laser equipment (the semiconductor lasers) which is small, light-weight and cheap is developed, and the optimal wavelength is investigated by measuring the temperature change of melanin in some wavelengths with several kinds of semiconductor lasers. In this paper we investigate an optimal wavelength of strong interaction between light and a melanin by measuring the temperature change of the hair when infrared lasers are irradiated.

2. The Wavelength Dependence of the Absorption Coefficient

The wavelength dependence of the absorption coefficient for water is shown in ref. 1, one for an oxy-hemoglobin and melanin are also shown in ref. 2, and one for oxyhemoglobin and the deoxidization hemoglobin are shown in ref. 3. In ref. 1, it is found that the absorption coefficient for water is in minimum value at 500nm and it gradually increases as a wavelength increase. For the oxy-hemoglobin, the absorption coefficient decrease rapidly above 650nm and in the region of 650-750nm it is very small, according to ref. 1, 2. Also, as for the deoxidization hemoglobin, it finds that the absorption becomes small above 600nm but tailed to longer wavelength compared with it of the oxyhemoglobin. On the other hand, for melanin it decreases gently by from 300nm (ultra violet) to 1100nm (infrared). Therefore, absorb only melanin efficiently, an oscillation wavelength around 700nm is thought to be optimal. The absorption coefficient of the skin and the influence over the actual human body are further problem in the future.

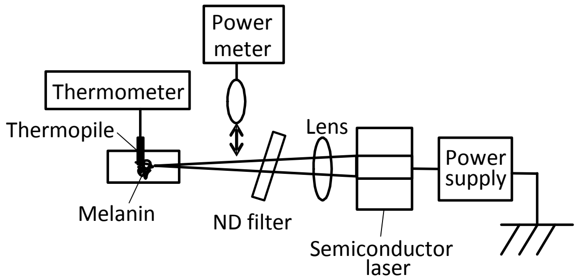

Fig 1. Experiment setup

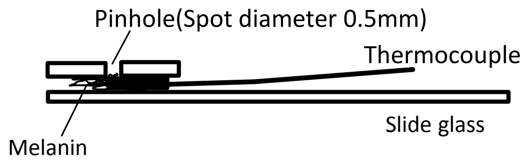

Fig 2. Sample state

3. Experiment Setup

A cure concept of using semiconductor laser equipment is shown in Fig.1. In this paper, a semiconductor laser is operated as a constant circuit. An oscillating wavelength area is infrared. Since the perpendicular beam-spreading angle is large due to diffraction of the joining surface of the semiconductor laser, output power is focused through the lens in order to improve the energy density. After that, a laser is irradiated to the affected region, it give the

Table 1: Compare semiconductor lasers using in this investigation with medical lasers

	Medical leasers on the market			Leasers used investigation	
Items	A	B	C	L785P090	DL-7140-201F
Laser Type	Flash lamp-pumped alexandrite laser	Diode laser	Nd:YAG laser	Diode laser	Diode laser
Wavelength [nm]	755	810±20	1064	785	781
Spot Size [mm]	8, 10, 12, 15	12, 8, 4	3, 5, 10	Continuously Variable	Continuously Variable
Fluence (Power)	Unknown	575J/cm^2	5-200J/cm^2	Changes by Spot Size (100mW)	Changes by Spot Size (100mW)
Pulse Width	3ms	50-1000ms	10-100ms	CW	CW
Size	Large	Middle (Table top)	Large	Small	Small
Price	Expensive	Expensive	Expensive	Cheap	Cheap
Application	Pigmented Lesions, Hair Removal	Hair Removal	Hair Removal	------	------

energy to melanin with high absorption coefficient for an infrared light and it can be applied to the removal of the bristletail and the body hair.

In the experiment setup shown in Fig. 1, the semiconductor laser Thorlabs:L785P090 (785nm, 90mW) and SANYO:DL-140-201F (785nm, 70mW) are used. The glass aspheric lens Thorlabs:C-230TM-B (f=4.5mm, AR Coated 600-1050nm) is used.

4. Experimental Results

In this experiment, we used two semicondector lasers (L785P090, DL-140-201F) to investigate the temperature rise to melanin for the wide laser wavelength range (L785P090: 785.42-787.15nm, DL-140-201F: 780.37-782.90nm) the wavelength (λ) was changed by the operation current ($I_{O}P$). The laser wavelength was measured using a spectrometer (Ocean Optics: USB 2000). The spot size is 0.5 mm in diameter, an irradiated power is control to 15 mW by the ND filter, and an operation temperature is fixed 25.0 ° C. Moreover, the spot size can be continuously changed by the focus lens.

Five mens hair sample (Japanese, age 20 years old, length: 1 mm, color: black) were used as samples. Fig 2. shows the state of the sample. The sample and the thermocouple are sandwiched between a slide glass and cardboard (pinhole with a diameter of 0.5 mm).

Table 2, 3 shows the temperature rise of the hair. The temperature rise indicates the difference between the temperature before irradiation (25°C) and it after 100 seconds irradiation. For the five samples (A-E), the largest temperature rise is occurred when 786.84nm (λ =) in the case of L785P090 (Table 2). For the five samples, the largest temperature rise is occurred when 781.01nm (λ =) in the case of DL-7140-201F (Table 3).

Fig. 3 shows the temperature rise for overall wavelength in this experiment. It is shown that the temperature rise is the largest when λ=781.01nm (DL-7140-201F).

Table 2 Temperature rise with wavelength (L785P090)

Wavelength (nm)	Sample A	Sample B	Sample C	Sample D	Sample E
785.42	13.20	14.40	13.60	13.50	13.10
785.90	12.20	13.20	13.00	12.60	12.30
786.21	12.50	13.60	13.20	12.80	12.50
786.84	14.40	15.30	14.90	14.80	14.30
787.15	13.90	14.70	14.20	14.10	13.60

Table 3 Temperature rise with wavelength (DL-7140-201F)

Wavelength (nm)	Sample A	Sample B	Sample C	Sample D	Sample E
780.37	14.70	14.50	14.10	14.90	14.00
781.01	15.40	15.20	15.00	15.60	14.80
181.64	14.30	14.20	14.00	14.50	13.80
782.43	15.10	14.90	14.60	15.20	14.50
782.90	13.70	13.60	13.40	13.80	13.30

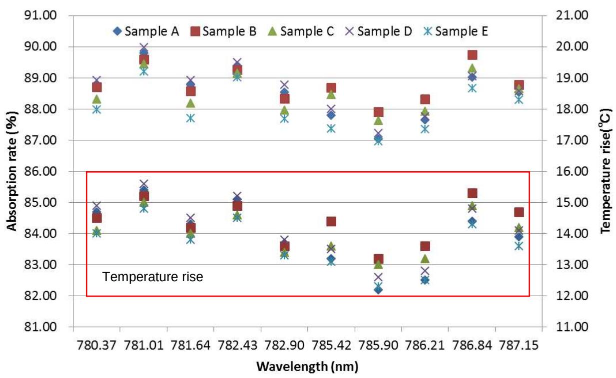

Fig 3. Comparison of temperature rise with wavelength

5. Conclusion

In this paper, we consider a dependence of wavelength on a temperature rise of a melanin. As a result of comparing temperature rise using two semiconductor lasers, it was found that the temperature rise is the largest when the wavelength is 781.01 nm (DL-7140-201 F). This wavelength is effectively absorbed to the melanin for the 780.37-785.42nm wavelength range.

In the future, we will investigate about pulse width etc. using these lasers. In the future, we will investigate the influence of CW oscillation and a pulse oscillation and pulse width. Moreover, we also investigate the influence of the 1/f fluctuation with an affinity for the rhythm of a human body.

References

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