Asian Journal of Physics
Vol. 25, No 4 & 5 (2016) 567-571
Available on: www.asianjournalofphysics.in

Testing Retina of Cataract Eye Using Speckle Pattern

Suganda Jutamulia[1], Erning Wihardjo[2] and Joewono Widjaja[3]
[1]*University of Northern California, Rohnert Park, CA 94928, USA*
[2]*KridaWacana Christian University, Jakarta,11470, Indonesia*
[3]*Suranaree University of Technology, Nakhon Ratchasima 30000 Thailand*

Dedicated to Prof FTS Yu

We are currently performing the theoretical study and developing the design of laser diode device for testing the retina of a cataract eye. The operation is based on the speckle generated on the retina by the cataract lens, when the cataract lens is illuminated with a coherent laser light.

Keywords: Retina, Cataract lens,UV light, Speckles

1 Introduction

Cataract is an eye disease that may develop in tropical countries having excessive UV light in the sun light. Because of the interaction with the UV light, the material in the lens of an eye may gradually turn to opacity. When the lens turns opaque, the patient may lose his or her vision and practically becomes blind. A number of clinics and hospitals are helping cataract patients especially in developing tropical countries. For example, Krida Wacana Christian University (UKRIDA) has health centers providing helps for cataract patients. The centers may provide eye surgery removing the opaque lens from the eye, and replacing it with an IOL (intra ocular lens).

In some occasion, a surgery may not be needed because the retina of the patient may already be defective. In this situation, although the opaque lens is removed and replaced with an IOL, the patient may not be able to see because the retina is defective or does not function properly. Accordingly, a test for the functionality of the retina may need to perform prior to the cataract lens removing surgery.

To test the functionality of the retina, a beam of light may illuminate the cataract eye. A healthy retina may sense the illuminating light. However since the light passes through the cataract lens, which is a light diffusing body, the patient can see only a blurred pattern. In other words, the light pattern formed on the retina has only very low spatial frequencies. Thus, the sensitivity of high spatial frequencies of the retina cannot be tested. A device that is able to test the high spatial frequency sensitivity of the retina of a cataract eye is proposed.

2 Theory

Coherent light may be used in the testing of the retina of a cataract eye. Two-beam interference through a cataract lens forming an interference pattern on the retina was proposed by Green [1]. Jutamulia and Gheen [2] proposed using a laser diode to form a speckle pattern on the retina though the cataract lens. The speckle size can be controlled by controlling the size of the illuminating light. The speckle size is inversely proportional to the illuminating beam size. Thus gradually changing the illuminating size provides gradually

Corresponding author :
e-mail: suganda@sbcglobal.net (Suganda Jutamulia)

change of the formed speckle size on the retina. In other words, the spatial frequency of the generated speckle pattern can be controlled. Accordingly, the sensitivity of the retina against the spatial frequency may be tested prior to the cataract eye surgery.

Figure 1 shows a model of the eye having cornea, lens, and retina. Under long time exposure to the UV light, the proteins of high molecular weight in the lens cells aggregate to be approximately 100 nm or more in size. For normal function, the proteins should remain dissolved in the lens cells. Problems start when proteins crystallize, or separate out of solution. They clump and scatter light away from the retina. The irregularly distributed aggregated proteins may cause the lens function as a light diffuser as shown in Fig. 2.

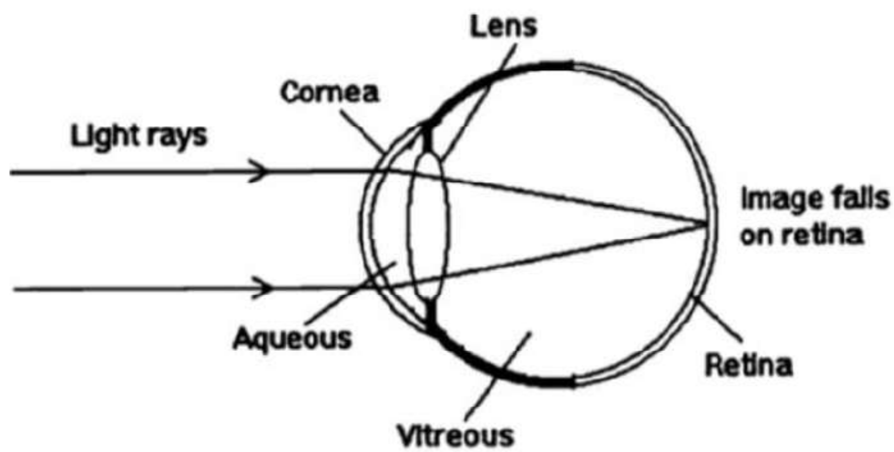

Fig. 1. Model of the eye having cornea, lens, and retina.

Figure 2 shows a collimated beam of coherent light illuminates the cataract eye. The collimated beam is focused by the lens onto the retina. If there is no cataract portion of the lens, the collimated beam is fully focused on the retina as shown in Fig 1. If there is cataract portion of the lens, a speckle pattern is formed on the retina. The size of the formed speckle is inversely proportional to the size of the illuminating collimated beam. Both sizes are related by a Fourier transform relation [2].

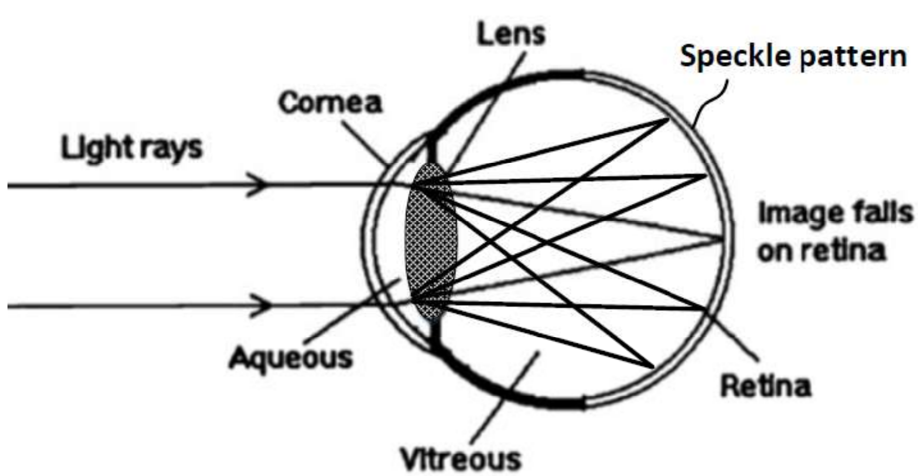

Fig. 2. Speckle pattern is formed on the retina by cataract portion of the lens.

By gradually decreasing the size of the illuminating collimated beam (i.e., the diameter of the illuminating light), the size of the formed speckle is gradually increasing. In other words, the high spatial frequency components of the formed speckle decrease. By testing the visibility at different spatial frequencies, the functionality of the retina may be determined. For example, at a stage, the patient may not be able to see clearly the speckle. The stage indicates that the retina sensitivity is limited to the spatial frequency corresponding to the stage. On the other hand, if the retina is fully not functioned, the retina may not sense any light from the beginning.

3 Laser Light Exposure Limit

Laser light is danger if it is directly directed to the eye. The maximum permissible exposure (MPE) is the highest power or energy density (in W/cm^2 or J/cm^2) of a light source that is considered safe, i.e., that has a negligible probability for creating damage. The MPE is measured at the cornea of the human eye or at the skin, for a given wavelength and exposure time. MPE as power density versus exposure time for various wavelengths is shown in Fig. 3 [3].

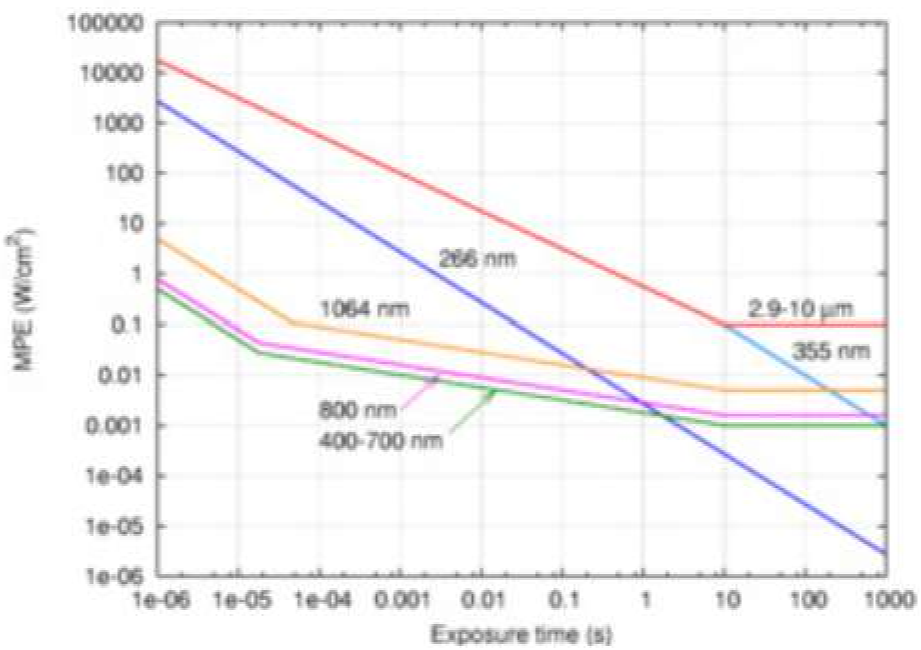

Fig. 3. MPE as power density versus exposure time for various wavelengths.

In the proposed device, the exposure time is set at 0.25 second, which is the human aversion response time. According to Fig. 3, the MPE is between 0.001 and 0.01 W/cm^2

Figure 4 shows a lens for collimating the beam emitted by a diode laser [4]. The lens is formed by a vertical cylindrical lens and a horizontal cylindrical lens. The vertical cylindrical lens collimates the beam in horizontal direction, and the horizontal cylindrical lens collimates the beam in vertical direction. Thus, a circular collimated beam can be produced. Alternatively, a regular spherical lens may be used for collimating the laser diode beam. However the collimated beam will have an elliptical cross-section instead of circular shape. The diameter of the circular collimated beam or the short diameter of the elliptical collimated beam can be made10 mm. For example, a 9 mm TO can laser diode may be used as shown in Fig. 5 [4].

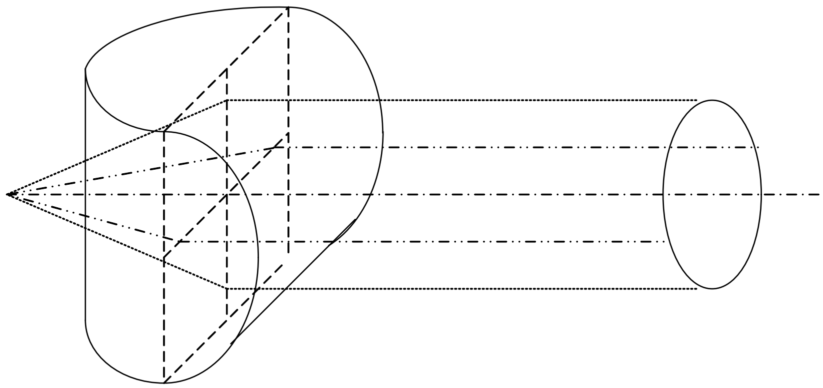

Fig. 4. Collimating lens is formed by a vertical cylindrical lens and a horizontal cylindrical lens.

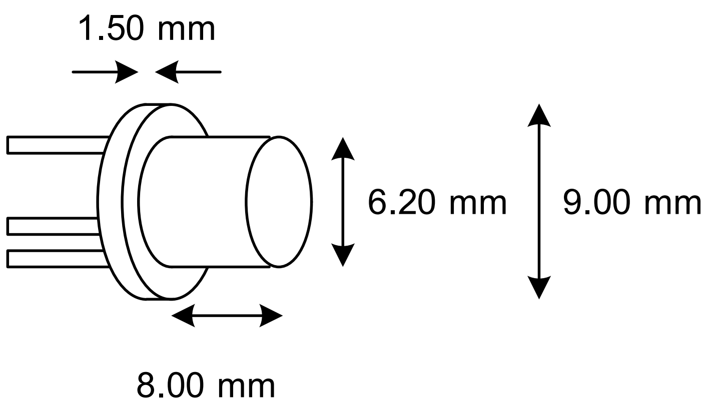

Fig. 5. 9 mm TO can laser diode.

If the laser diode emits light having 1 mW power, the laser light is collimated in a circular cross-section having diameter of 10 mm or 1 cm, the power density will be approximately 1.27 mW/cm^2. Accordingly, a laser diode of Class II, which emits visible light of less than 1 mW, may be used.

4 Device and Operation

The testing device is depicted in Fig 6. A laser diode emits laser light. The emitted laser light is collimated by a collimating lens. The lens may be the collimating lens of Fig 4 or a regular spherical lens. A variable aperture controls the diameter of the light illuminating the eye. The illuminating light passes through a beamsplitter. Part of the illuminating light is reflected by the beamsplitter. The reflected light is focused by a focusing lens and detected by a detector. The detected light power is analyzed by a power analyzer, if the detected power is larger than a permissible maximum value, the power of the laser diode is shut off.

The laser diode is powered by a power supply, which supplies the electric current to the laser diode. The power provided to the laser diode is controlled by a power control. The laser diode is turned on by periodical pulses. Each pulse is 0.25 second.

The testing may be conducted by slowly increasing the power of the laser diode from zero until the patient can see the generated speckle pattern. Then the size of the illuminating light is decreased. The patient should see that the size of the spackle pattern increases, if the retina still functions normally.

If the laser diode emits light having power larger than the permissible maximum value, the power analyzer will shut off the laser diode.

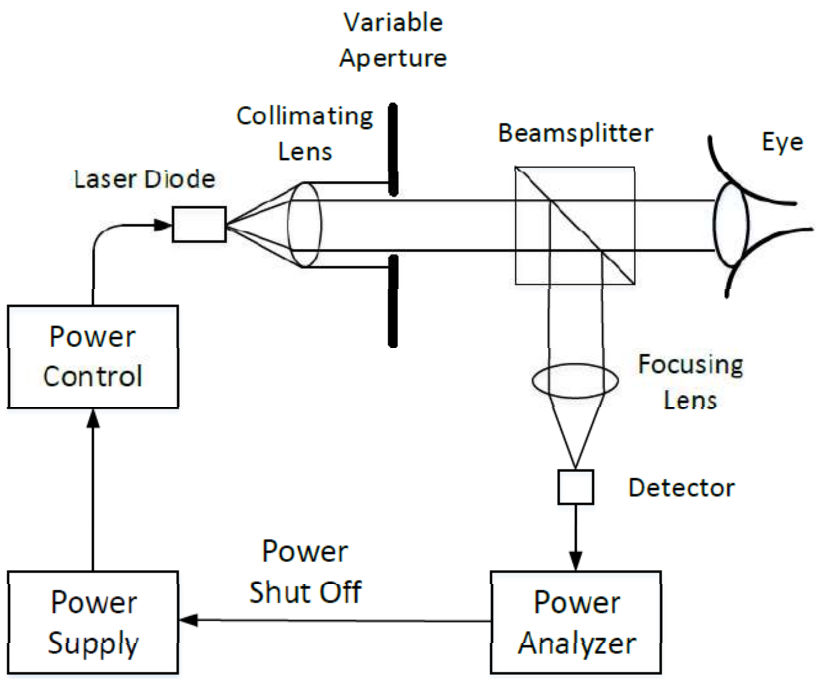

Fig 6. Schematic diagram of the proposed testing device.

We are currently performing the theoretical study and the design of the proposed device. After the device is successfully made, it is planned to test the device in the facility of Krida Wacana Christian University.

References

1. Green D G, Testing the vision of cataract patients by means of laser-generated interference fringes, *Science*, 168, (1970)1240-1242.
2. Jutamulia S, Gheen G, Diffraction pattern on retina for eye testing, *Opt Eng*, 34(1995)780-784.
3. Wikipedia, "Laser safety," https://en.wikipedia.org/wiki/Laser_safety (2016).
4. Jutamulia F Z, Laser module for acupuncture, *Asian J Phys*, 24(2015)237-242.

[*Received*: 1.1.2016]