Repetitive X-Ray Source by Triboluminescence

Seizo FURUYA

Saitama Institute of Technology, Fukaya 369-0293 JAPAN

ABSTRACT

Triboluminescence is a luminous phenomenon resulted from friction; for example, peeling scotch tape, breaking rock sugar with a hammer, peeling mica and so on. Triboluminescence is well known over 50 years but in 2008 UCLA group reported the radiation of x-ray region by triboluminescence in vacuum for the first time. UCLA group made an automatic machine which peels scotch tape. With a view to practical application of triboluminescence to roentgen diagnosis we have attempted a new-type triboluminescence equipment.

Keywords

triboluminescence, x-ray source, continuous operation

1. Introduction

Triboluminescence is a luminous phenomenon resulted from friction; for example, peeling scotch tape, breaking rock sugar with a hammer, peeling mica and so on. Triboluminescence is well known over 50 years but in 2008 UCLA group reported the radiation of x-ray region by triboluminescence in vacuum for the first time.[1)] UCLA group made an automatic machine which peels scotch tape. With a view to practical application of triboluminescence to roentgen diagnosis we made an automatic peeling machine similar to that of UCLA group. An x-ray tube for conventional roentgen diagnosis needs a high voltage power supply. In contrast, triboluminescence does not need it. So it is very useful for roentgen diagnosis to replace a conventional x-ray tube with triboluminescence.

So far, we have made an automatic peeling machine similar to that of UCLA group and have confirmed the visible light and x-ray emissions from the peeling tape. The visible light emission from peeling tape seems continuous by the naked eye but we have verified using a photomultiplier that the peeling tape emits light in pulses actually. At first, we have confirmed the x-ray generation from triboluminescence using a filtered phosphor screen when the parameters such as the followings are changed; peeling speed, atmospheric pressure, variety of scotch tape, emission angle etc. Then in a similar way we have successfully measured the x-ray dose from triboluminescence using a potable dosemeter. It was found that the x-ray generation from triboluminescence has a directional property.

Because the method to peel scotch tapes does not enable to operate continuously, new method without scotch tapes has been proposed.[2-3)] The new method repeatedly contacts silicone with epoxy to produce x-ray. In this report, we have reported a novel method to generate x-ray radiation by triboluminescence. Two circular discs are contacted and rotated: One is made of silicone and another is made of epoxy.

2. Experimental Setup

We made an automatic peeling machine similar to that of UCLA group. Figure 1 shows a photograph of the machine. A geared motor of 200 RPM is used for a driving force.

Figure 2 shows the vacuum pump system. A turbo molecular pump (TMP) and a rotary pump (RP1) are a pair (PFEIFFER VACUUM, Turbomolecular Drag Pumping Station TSH261 with DUO2.5). The pumping speed of RP1 is 2.5 m3/h and total pumping speed is 210 L/s. To enhance the pumping capability RP2 (SHINKU KIKO, GVD-135A, 135 L/m) is added.

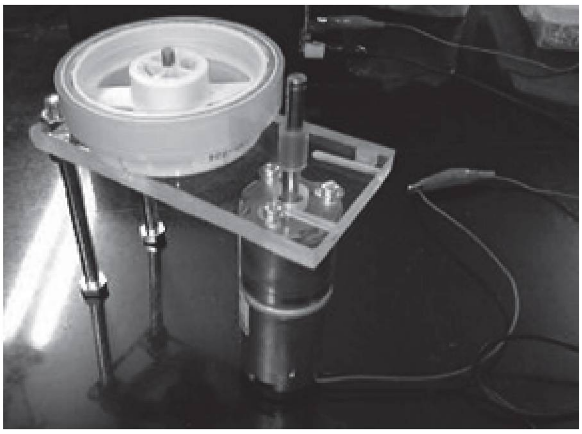

Figure 1　Photograph of automatic peeling machine

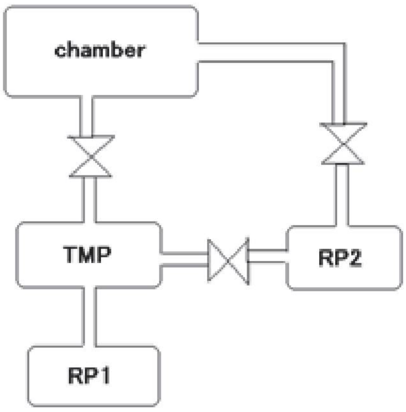

Figure 2　Vacuum pump system

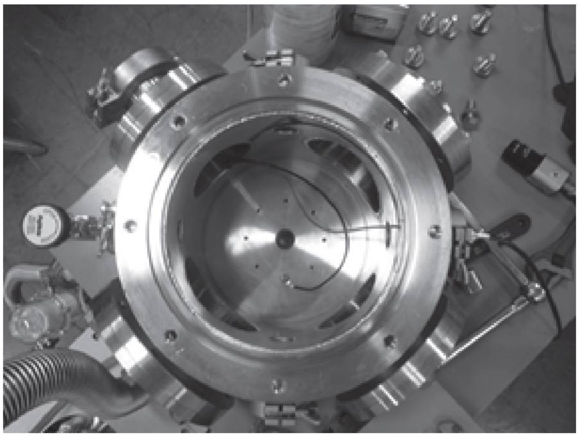

Figure 3　Photograph of vacuum chamber

Figure 3 shows a photograph of the vacuum chamber. The inner diameter is 210.7 mm and the inner height is 200 mm

3. Results and Discussion

3.1 Confirmation of x-ray generation

A thin piece of plastic scintillator (OKEN, NE102A) was put near the peeling tape to confirm the generation of x-ray. In this report, a phosphor screen was used to detect the x-ray, as shown in Fig.4. The phosphor screen is PHOS-RP22SS-C5x5-R1000(Rugged) manufactured by Kimball Physics. Figure 5 shows an open-shutter photograph of emission of visible light from peeling tape and the phosphor screen in vacuum. The phosphor screen emits visible light when irradiated with x-ray, and it is found that the phosphor screen emits light in the photograph. The photograph was taken by turning off a room light and covering the vacuum chamber overall with a blackout curtain. Soon after peeling the tape, the pressure in the chamber started to increase. When the pressure was more than $7*10^{-3}$ torr, the plastic scintillator did not emit light. In this experiment, the pressure became $1*10^{-2}$ torr, balancing the outgas from peeling tape with the evacuation by vacuum pomp. At that pressure, the phosphor screen still emits visible light.

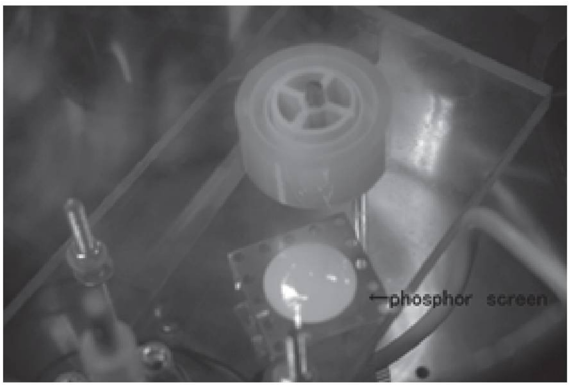

Figure 4　Experimental setup of phosphor screen

Figure 5 Photograph of light emission from peeling tape and phosphor screen

3.2 Measurement of x-ray dose

Figure 6 shows the experimental setup to measure the x-ray dose of upward direction. The x-ray dose was measured using a portable dosemeter(ALOKA, PDM-117). Figure 7 shows the time variation of pressure and accumulated x-ray dose. The dotted lines in the figure are the data in the case that the initial pressure was 1.0*10^{-3} torr and the peeling speed is 0.6-1.2 cm/s. The x-ray dose of 1 μSv was detected for 10-minute exposure. The broken lines are the experimental results in the case of 7.8*10^{-4} torr and 0.6-1.2 cm/s. When the initial pressure is low, the x-ray dose increases. When the peeling speed increases, the x-ray dose also increases? The continuous lines are the data in the case that the peeling speed is twice. The answer is no because the pressure rapidly increases.

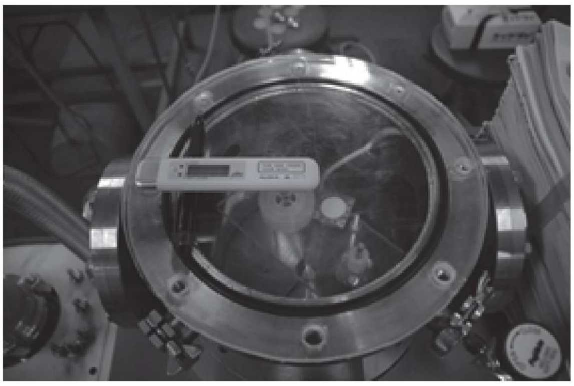

Figure 6 Experimental setup to measure x-ray dose of upward direction

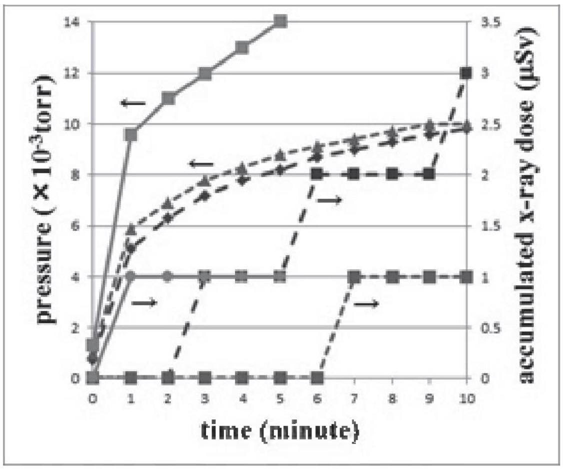

Figure 7 Time variation of pressure and accumulated x-ray dose

Figure 8 shows the experimental setup to measure the x-ray dose of traverse direction. The x-ray was not detected in this setup, so the x-ray was not radiated to the traverse direction.

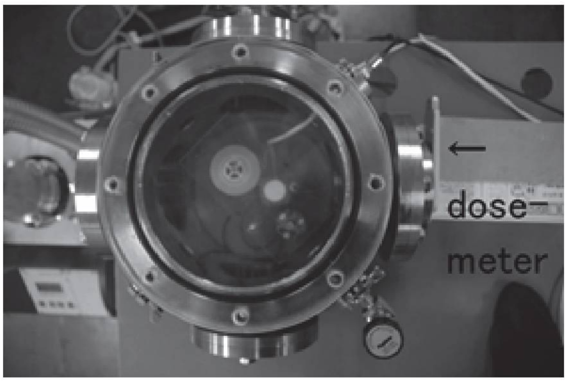

Figure 8 Experimental setup to measure x-ray dose of traverse direction

3.3 Continuous operation

As the method to peel scotch tapes does not enable to operate continuously, new method without scotch tapes has been proposed.[2-3] The new method repeatedly contacts silicone with epoxy to produce x-ray. In this conference, we have reported a novel method to generate x-ray radiation by triboluminescence. Two circular discs are contacted and rotated: One is made of silicone and another is made of epoxy. We have made a new-type triboluminescence equipment, shown in figure 9.

From now on, we examine its characteristics when the following conditions are changed; combinations of contact materials, rotating velocity, radiation direction, pressure and so on.

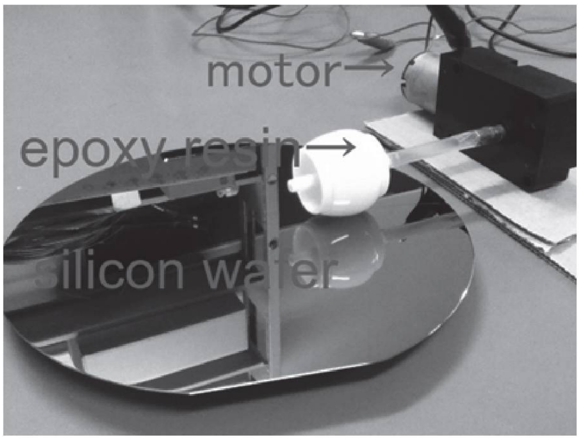

Figure 9 new equipment to generate x-ray continuously

4. Conclusions

We have made a new-type triboluminescence equipment to generate x-ray continuously. From now on, we examine its characteristics in detail.

References

[1] C. G. Camara et al., “Correlation between nanosecond X-ray flashes and stick-slip friction in peeling tape”, nature Vol.455 pp.1089-1092 (2008).

[2] K. Stefan, “A stroke of X-ray”, nature Vol.473 pp.455-456 (2011).

[3] J. R. Hird et al., “A triboelectric x-ray source”, Appl.Phys.Lett. 98, 133501 (2011).