VISUALIZATION AND PROTECTION OF RADIATION FOR EYE LENS EXPOSED BY SINGLE WEARABLE DOSIMETER

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Disclosure of conflict of interest

We have nothing to declare for this study.

Teaching Points

- ✓ **To understand the importance of visualizing and monitoring the radiation dose for eye lenses by wearable radio-photoluminescence (RPL) glass dosimeter.**

- ✓ **To understand the need for managing the occupational dose to reduce radiation exposure for eye lenses in radiology exams.**

- ✓ **To understand the importance of protecting medical staffs or caregivers attending to patients from radiation.**

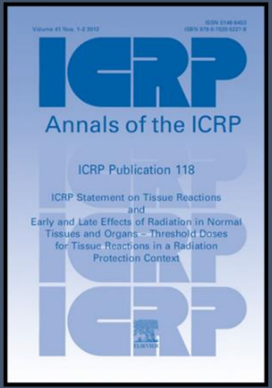
Equivalent Dose Limit for Eye Lens

- ✓ **Reduced the eye lens exposure limit from 150 to 20mSv/y by the International Commission on Radiological Protection (ICRP) in 2011**

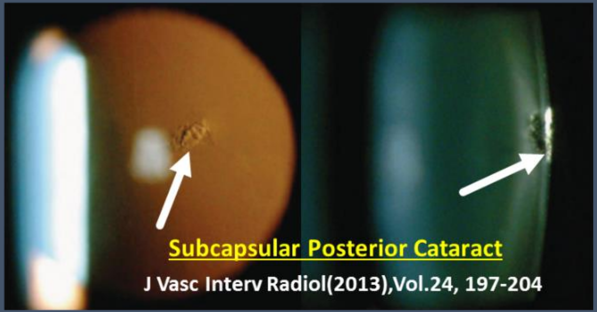
150mSv/y

ICRP publ.60 (1991)

(Medical regulation in japan)



Reduced approx. 1/8



20mSv/y (averaged 5y)

No single year exceeding 50mSv

ICRP statement (2011)

Introduction

- ✓ **Growing interest is being paid for local radiation exposure on the human eye triggered by the recommendation of ICRP.**

- ✓ **The risk of cataracts should be more strictly controlled and managed under the new regulation, effective in Japan from April 2021.**

Radiation dosimeter

Lumines Badge (OSL)

Glass Badge (RPL)

DOSIRIS (TLD)

Personal dosimeter (Semiconductors)

Radiation protection equipment

Protective glasses

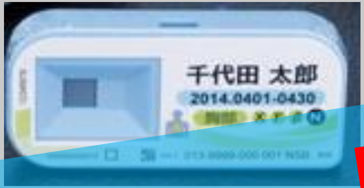
Ceiling-mounted protective plate

Protective Cloth

Radiation dosimeter

Lumines Badge (OSL)

Glass Badge (RPL)



DOSIRIS (TLD)

Personal dosimeter (Semiconductors)

+

Radiation protection equipment

Protective glasses

Ceiling-mounted protective plate

Protective Cloth

No

Dosimeter that Combines Both

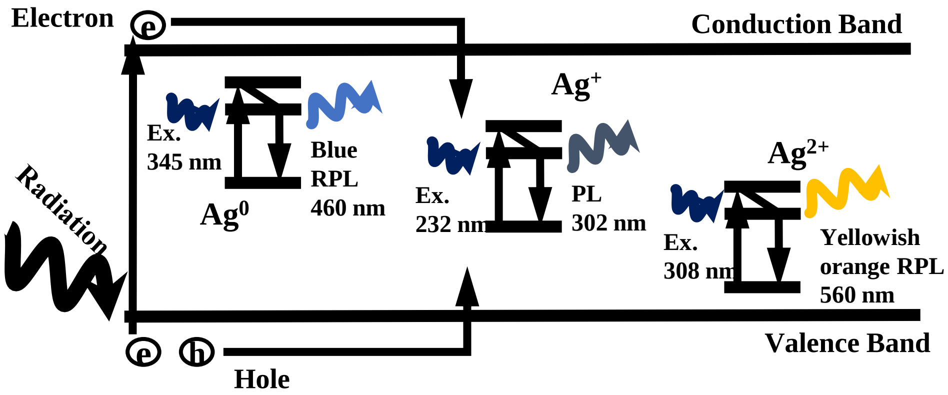
Visualization and Protection

Purposes

- ✓ **To develop a glasses-type wearable device that combines lens radiation dose measurement and protection, and conducted a basic performance evaluation.**

- ✓ **To demonstrate the feasibility of the developed dosimeter for visualization and protection at the same time.**

Principle of RPL for Radiation Measurement



RPL: radiophotoluminescence
(Fluorescent glass dosimeter)

$Ag^{+} + e \rightarrow Ag^{0}$ (Electron capture)
$Ag^{+} + hPO_4 \rightarrow Ag^{2+}$ (Hole Capture)

[3] Miyamoto et al., Radiation Chemistry, Vol. 94 (2012) 47-52.
[4] Ishikawa et al., JAERI-Tech 94-034 (1994).

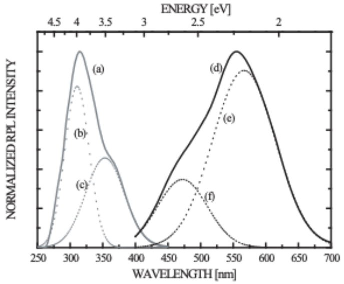


Fig 1. PLE spectrum of a typical RPL glass dosimeter. [3]

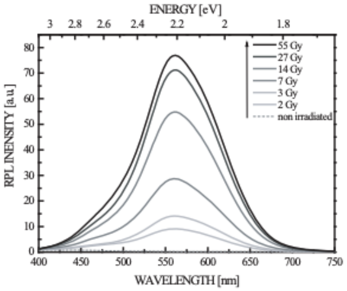


Fig 2. RPL spectrum of a typical RPL glass. [3]

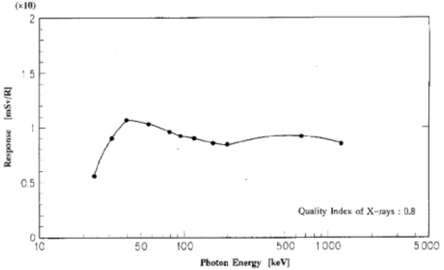
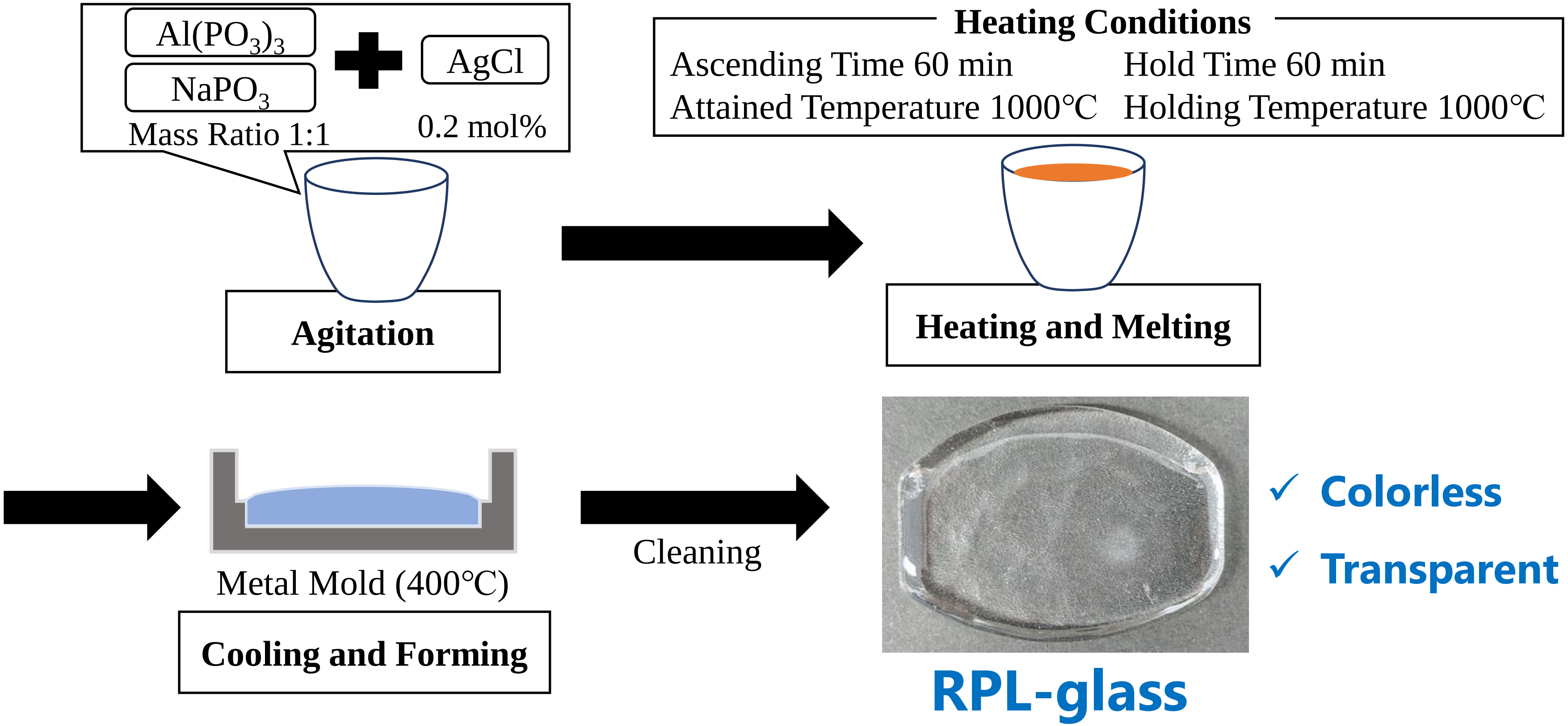


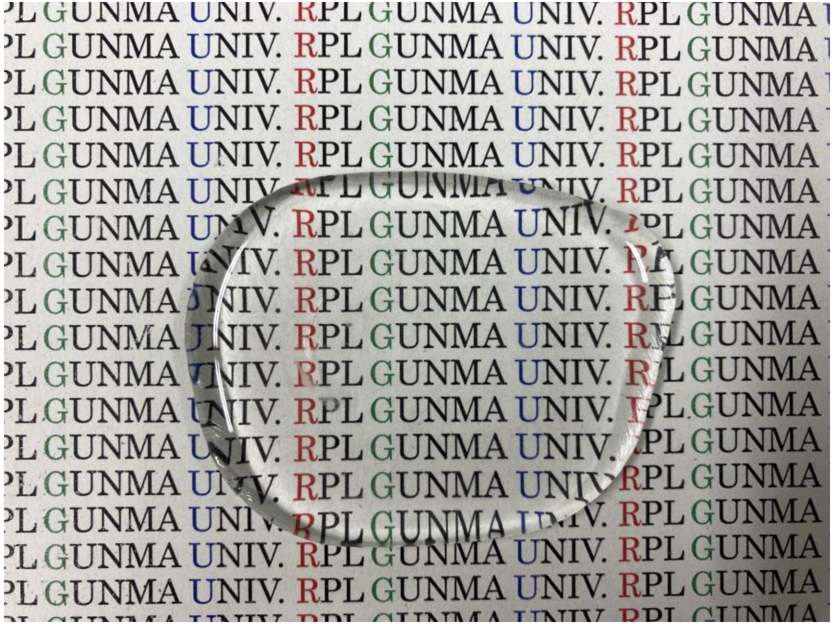
Fig 3. Example of energy dependence of a typical RPL glass. [4]

Preparation of RPL-glass

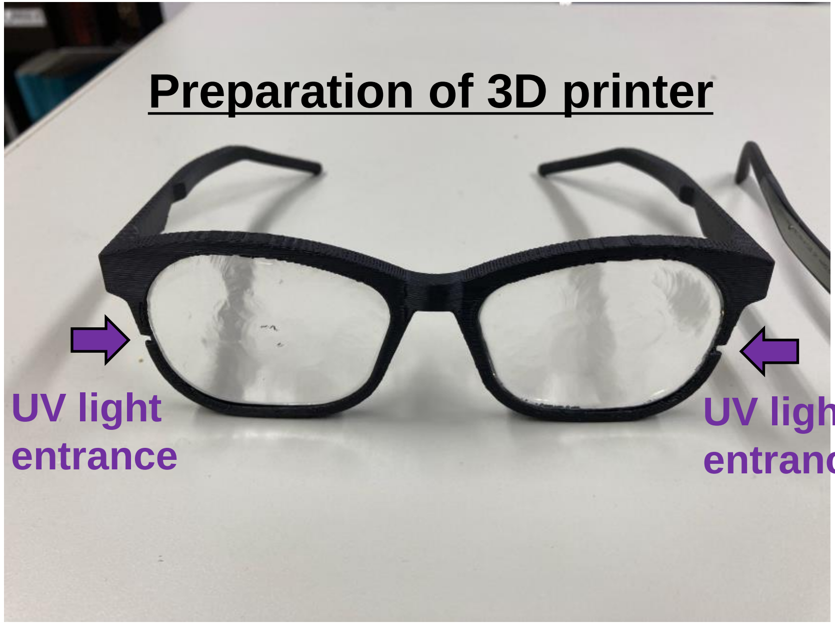


Development of a Prototype①
Wearable RPL Dosimeter

RPL-glass



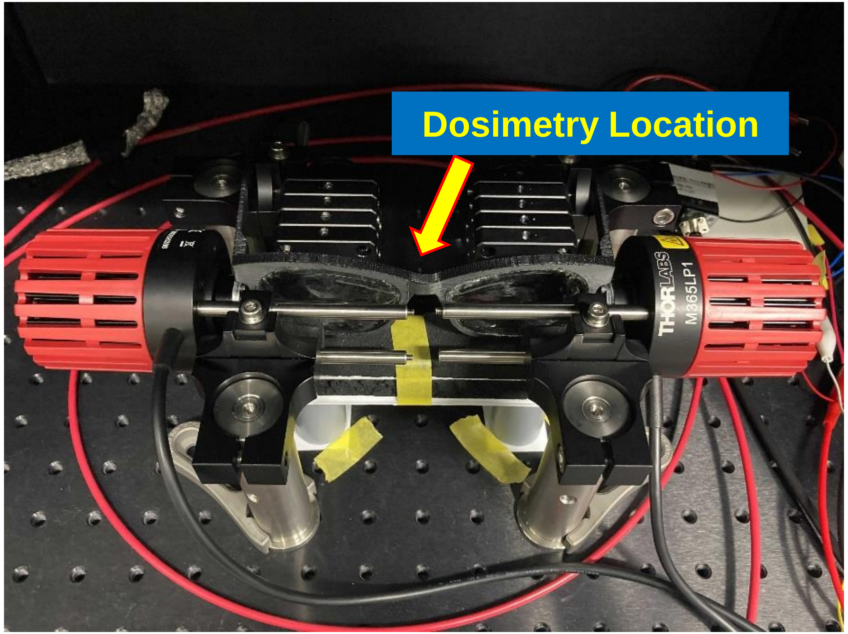
Glass frame of eyewear



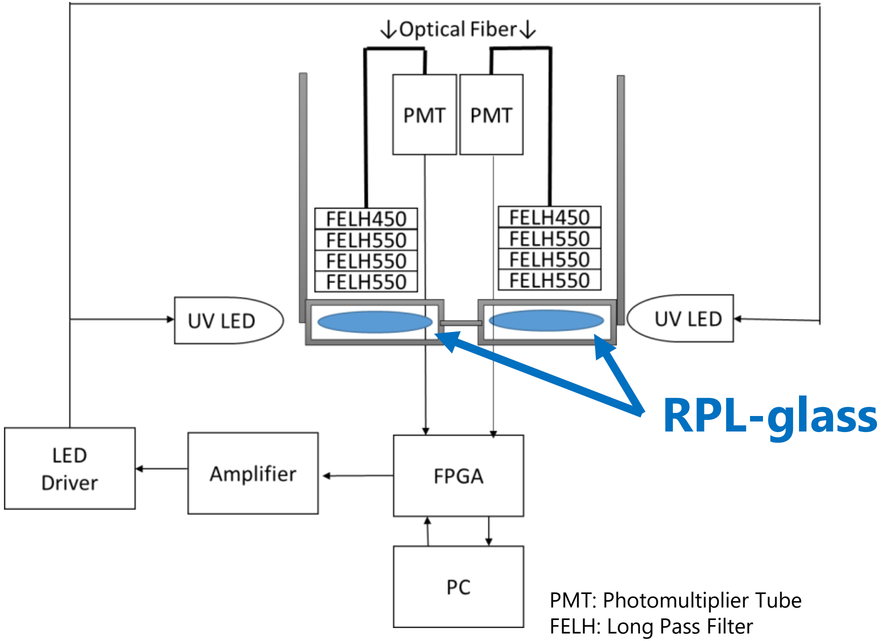
Vertical： approx. 38.80 ±0.90 mm、Horizontal： approx. 59.25 ±0.25 mm、Thickness : approx. 5.65±0.35 mm

Reader of RPL-glass Dosimeter

Equipment Appearance



Equipment Schematic



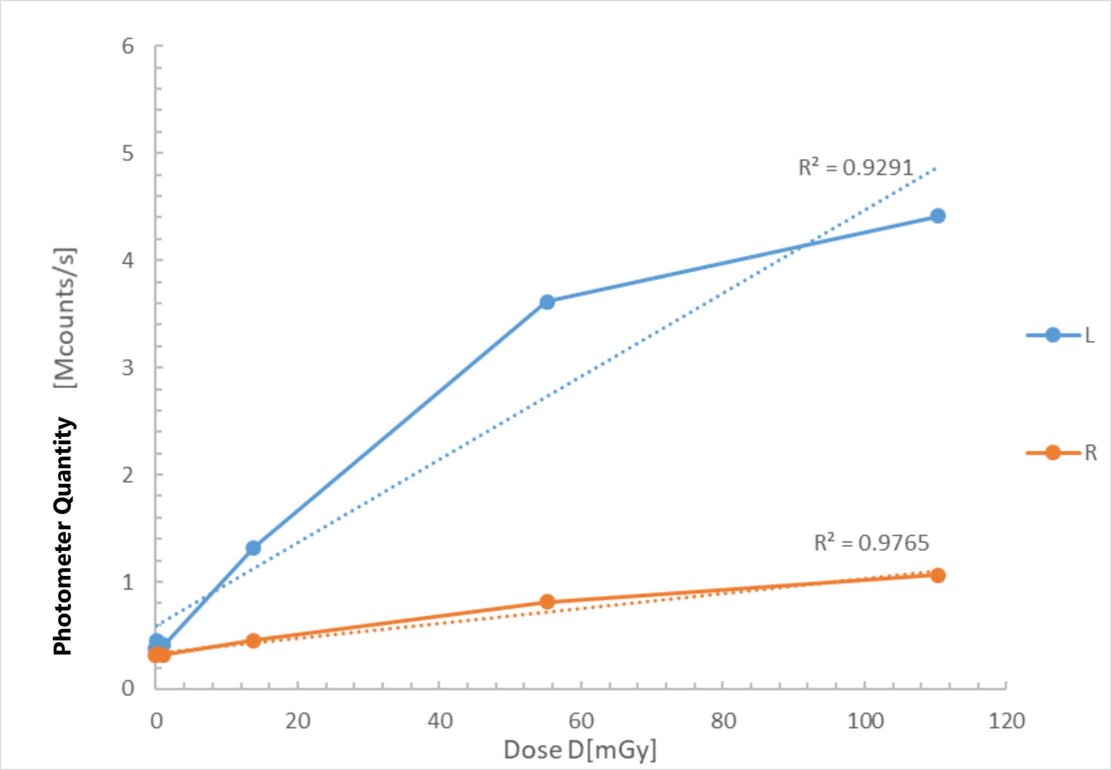
PMT: Photomultiplier Tube
FELH: Long Pass Filter
UV: Ultraviolet
LED: Light Emitting Diode
FPGA: Field Programmable Gate Array

Method①: Measurement and Protection Experiments

- ✓ **X-ray Machine: SHIMADZU UD150 B-10**
- ✓ **Irradiation Field: Left glass only**
- ✓ **Dosimeter for X-ray Output: RaySafe ThinX**
- ✓ **Glass Dosimeter: GD352M (for protective measurement)**

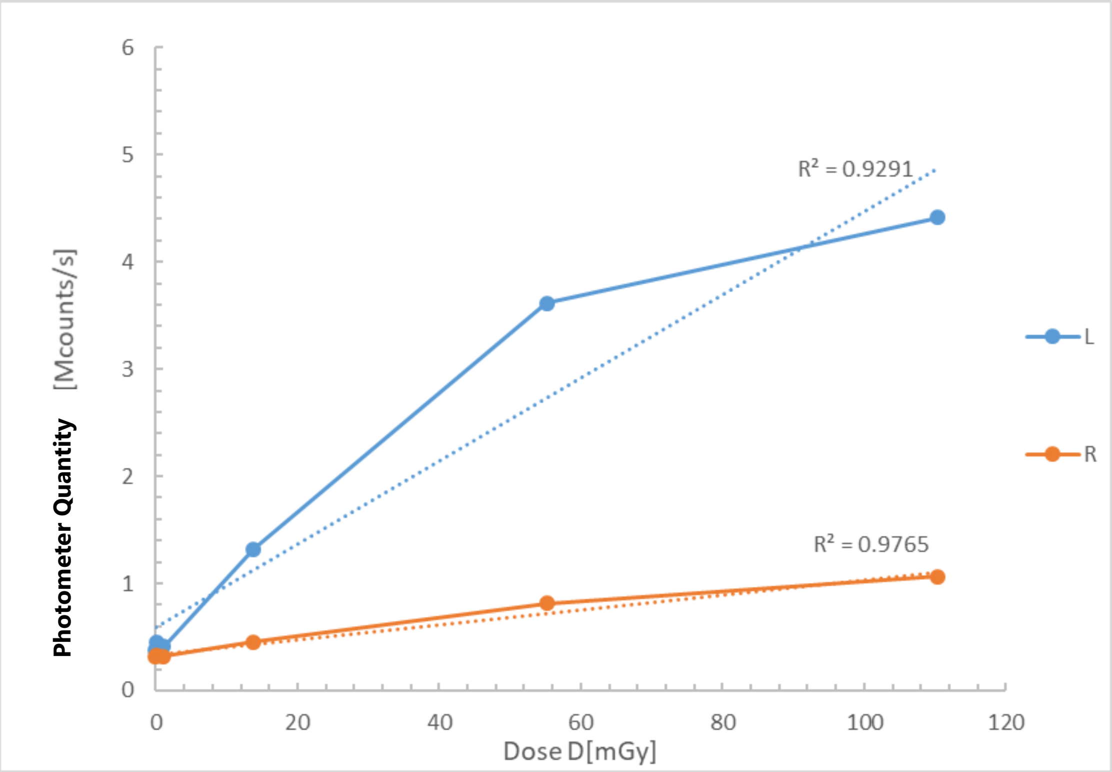
	Voltage [kV]	Current [mA]	Time [msec]	SID [cm]	No. of Exposure	Dose [μGy]
①	90	63	25	97	1	**141**
②	90	63	50	50	1	**1070**
③	90	200	200	50	1	**13800**
④	90	200	200	50	4	**55200**
⑤	90	200	200	50	8	**11040**

Result①: Visualization and Detection

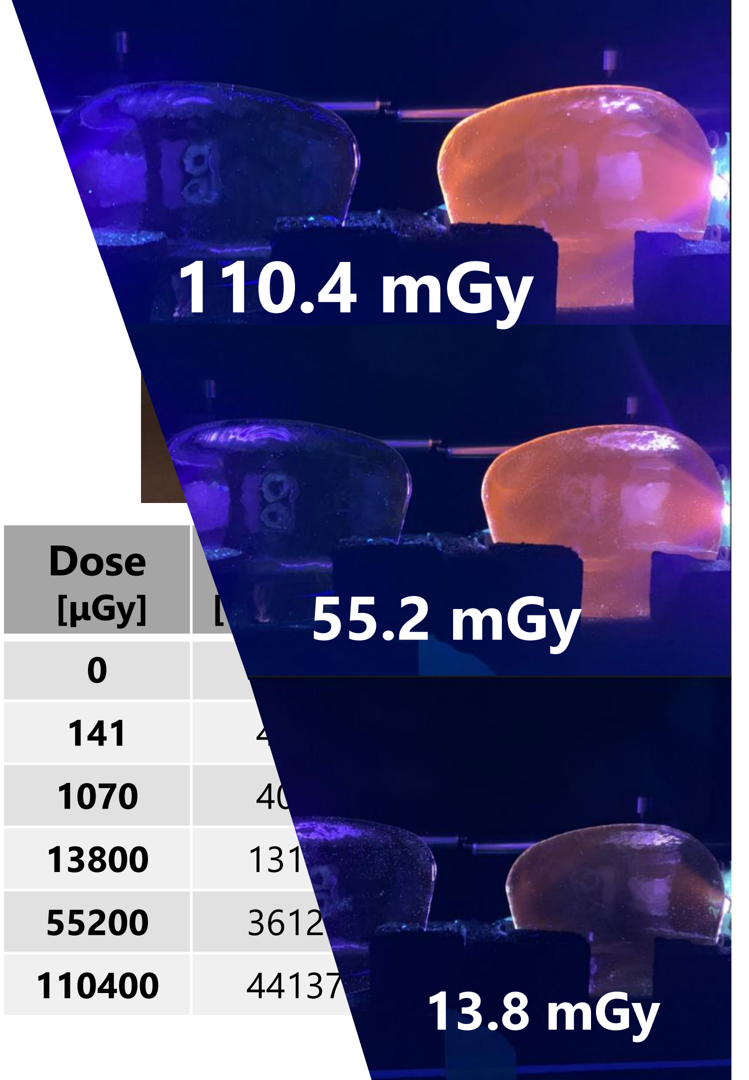


Dose [μGy]	Left glass [Mcounts/s]	Right glass [Mcounts/s]
0	371170	322000
141	447790	326930
1070	407900	319960
13800	1317750	454330
55200	3612860	813100
110400	4413790	1062100

Result①: Visualization and Detection



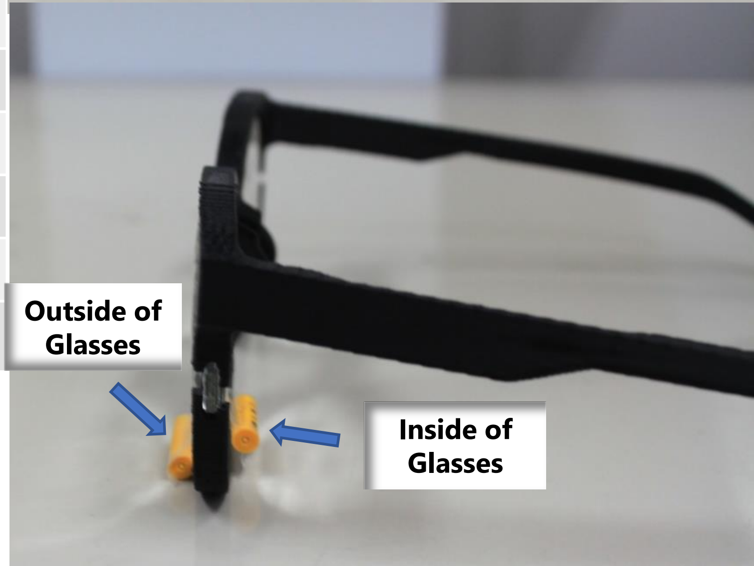
Dose [μGy]	[
0	
141	4
1070	40
13800	131
55200	3612
110400	44137



Result①: Radiation Protection Effect

	Glass Dosimeter [μGy]		[%]	[%]
Condition	Outside of glasses	Inside of glasses	Reduction Rate	Shielding Rate
①	202	122	60.4	**39.6**
②	1266	690	54.5	**45.5**
③	15730	7796	49.6	**50.4**
④	61960	29300	47.3	**52.7**
⑤	111000	59660	53.7	**46.3**
		Average	**53.1**	**46.9**

Shielding Rate [%] =
100- (Inside of glasses/Outside of glasses) ×100



Development of a Prototype②
Wearable RPL Dosimeter

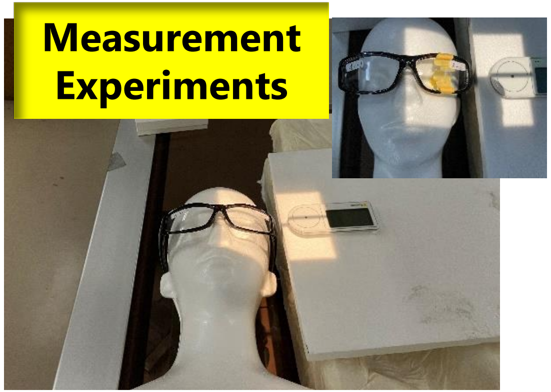
New Point

- ✓ **Polished and cleared glass surface**
- ✓ **Lenses inserted into commercially available eyeglass frames**
- ✓ **The thickness of the lens was created with 2, 3, 4 and 5 mm**

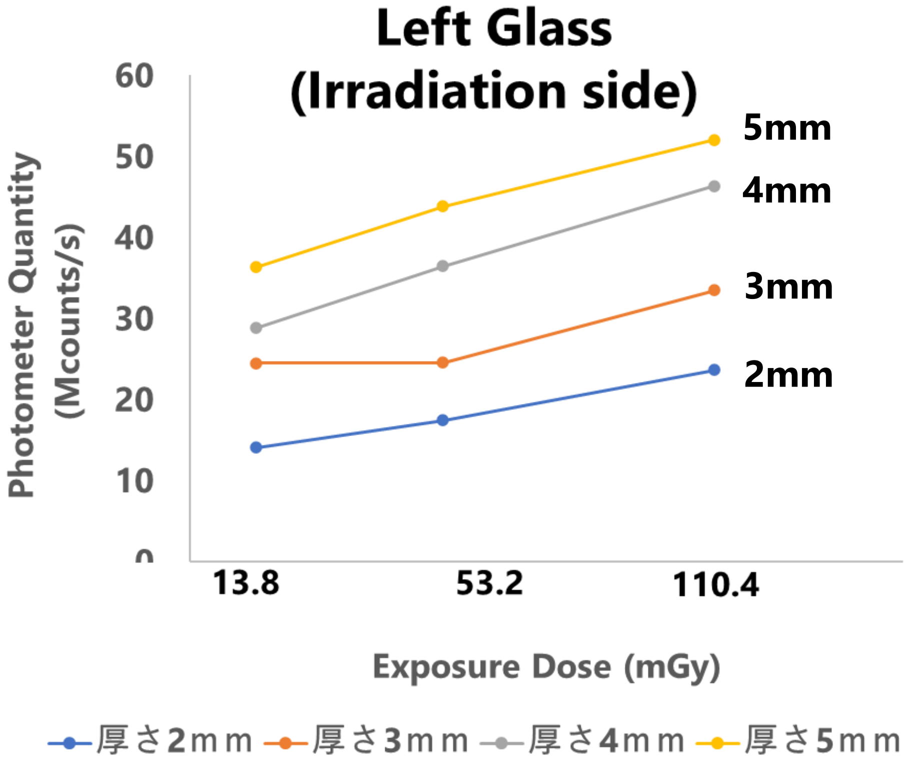
Method②: Measurement and Protection Experiments

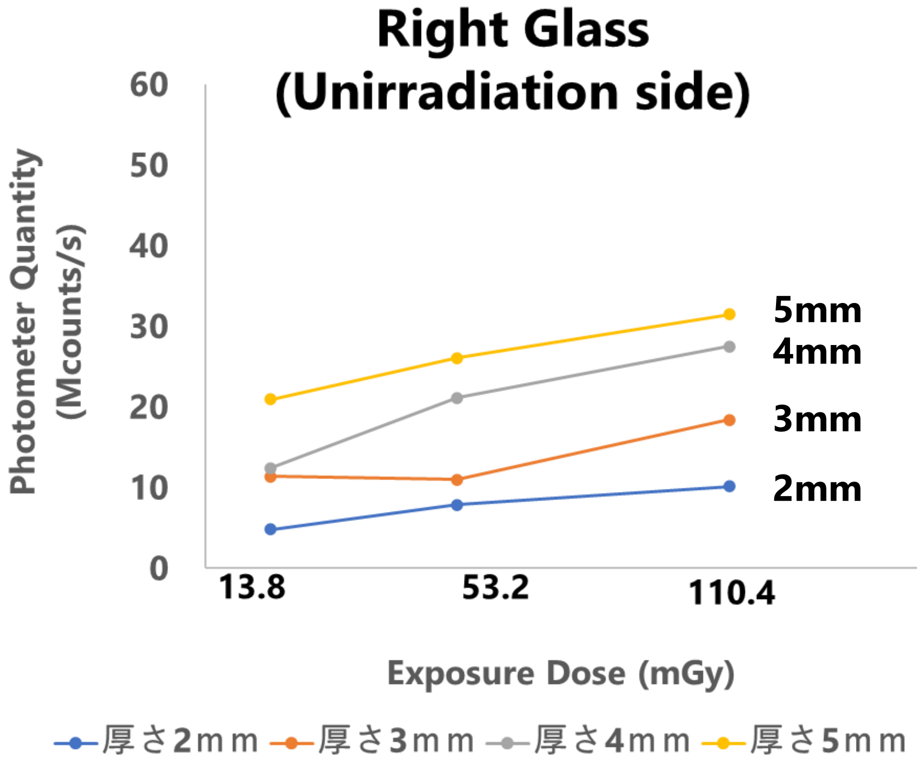
- X-ray Machine: SHIMADZU UD150 B-10
- Irradiation Field: Left glass only
- Dosimeter for X-ray Output: RaySafe ThinX
- Glass Dosimeter: GD352M (for protective measurement)
- X-ray Conditions: 2, 3, 4 and 5mm RPL-glass

	Voltage [kV]	Current [mA]	Time [msec]	SID [cm]	No. of Exposure	Dose [μGy]
①	90	200	200	50	1	**1380**
②	90	200	200	50	5	**6900**
③	90	200	200	50	10	**13800**

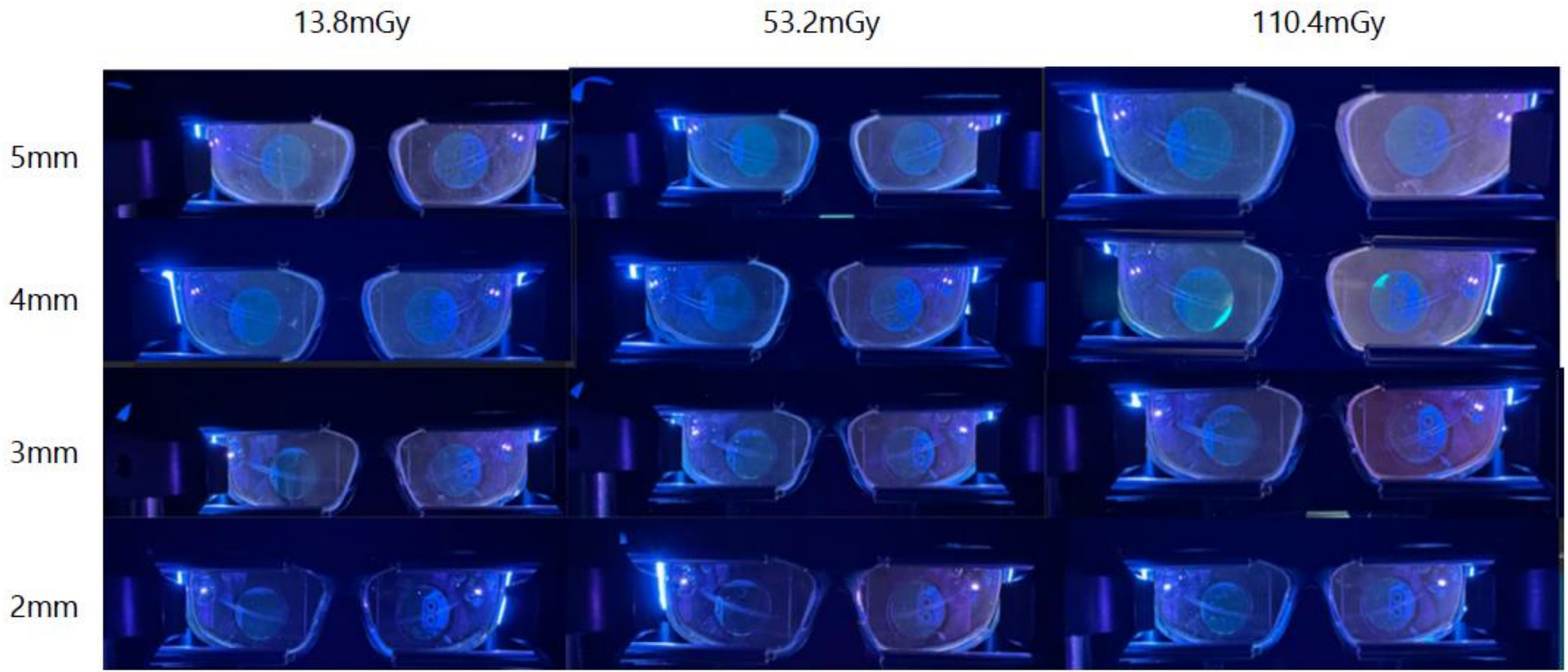


Result②: Visualization and Detection

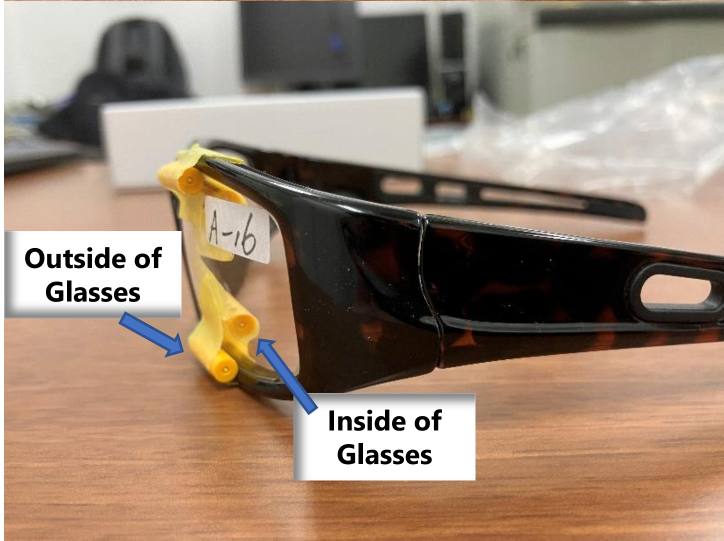




Result②: Visualization and Detection



	Glass Dosimeter [μGy]		[%]	[%]
Condition (Thickness)	Outside of glasses	Inside of glasses	Reduction Rate	Shielding Rate
① (2mm)	19522	12693	65.0	**35.0**
② (2mm)	93786	66269	70.7	**29.3**
③ (2mm)	196992	137755	69.9	**30.1**
① (3mm)	19092	12182	63.8	**36.2**
② (3mm)	98747	60110	60.9	**39.1**
③ (3mm)	184362	118619	64.3	**35.7**
① (4mm)	18640	10057	54.0	**46.0**
② (4mm)	93777	53616	57.2	**42.8**
③ (4mm)	183368	101594	55.4	**44.6**
① (5mm)	18856	9487	50.3	**49.7**
② (5mm)	92792	46006	49.6	**50.4**
③ (5mm)	186810	92425	49.5	**50.5**



Discussion①

Measurement Results

- ✓ **Left (irradiation-side): High correlation (R^2 = 0.9291)**
  - ☞**Visualization of lens exposure**
- ✓ **Right (unirradiation-side): High correlation (R^2 = 0.9765)**
  - ☞**Increase due to scattered radiation depending on the dose**

Protective Results

- ✓ **Protection Effect: Approximately 40%~53%**
  - ☞**Successful in both measurement and protection**

Discussion②

Measurement Results

- ✓ **Left (irradiation-side): High linearity depending on the thickness**

  ☞**Visualization of lens exposure**

- ✓ **Right (unirradiation-side): High linearity depending on the thickness**

  ☞**Increase due to scattered radiation**

Protective Results

- ✓ **Protection Effect: Approximately 30%~50% (2, 3, 4 and 5mm)**

  ☞**Successful in both measurement and protection depending on the thickness**

Discussion③

Measurement Results

- ✓ There is a dosimeter that can measure the vicinity of the eye (ref. ⑤ ～ ⑥)

☞ There are no eyeglass lenses that can measure radiation dose

Protective Results

- ✓ Many clinical studies on lead-containing protective glasses have shown a protective effect of 50~60% (ref. ⑦～⑫)

☞The development wearable eyeglasses showed comparable results

Conclusions

- ✓ The glasses-type wearable dosimeter that we prototyped this time was able to visualize the radiation dose in a dose-dependence
- ✓ In addition, it had a protective effect of about 50% at same time
- ✓ The dosimeter is a device that combines lens exposure dose measurement and lens exposure protection

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