RS8-91

Lift-off photolithography process for electrode preparation of TlBr gamma-ray detectors

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Introduction

SPECT(Single photon emission CT)

SPECT is an attractive nuclear medical device using gamma-rays emitting from drags accompanying isotopes and is helpful for diagnosis of brain diseases and cardiac diseases. In order to obtain isotope distribution showing physiology, gamma-ray detectors with multi-pixel electrodes are used for acquiring gamma-ray energy spectra of induced isotope in patient body.

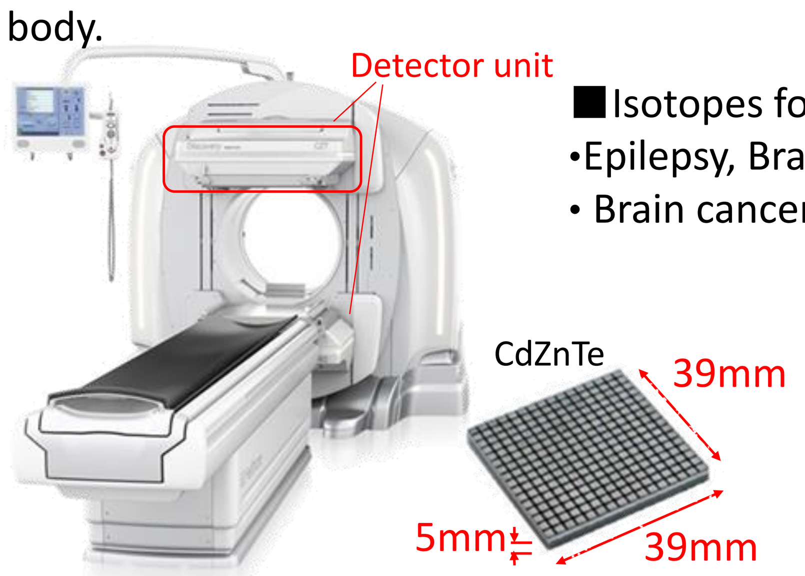


Fig.1. SPECT and CdZnTe detector (GE Discovery NM/CT670CZT)

■Isotopes for SPECT:

- Epilepsy, Brain infarction and Dementia (^{123}I)
- Brain cancer (^{201m}Tc)

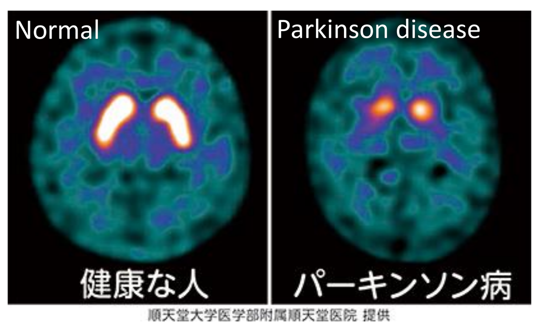


Fig.2. Brain diagnosis images.

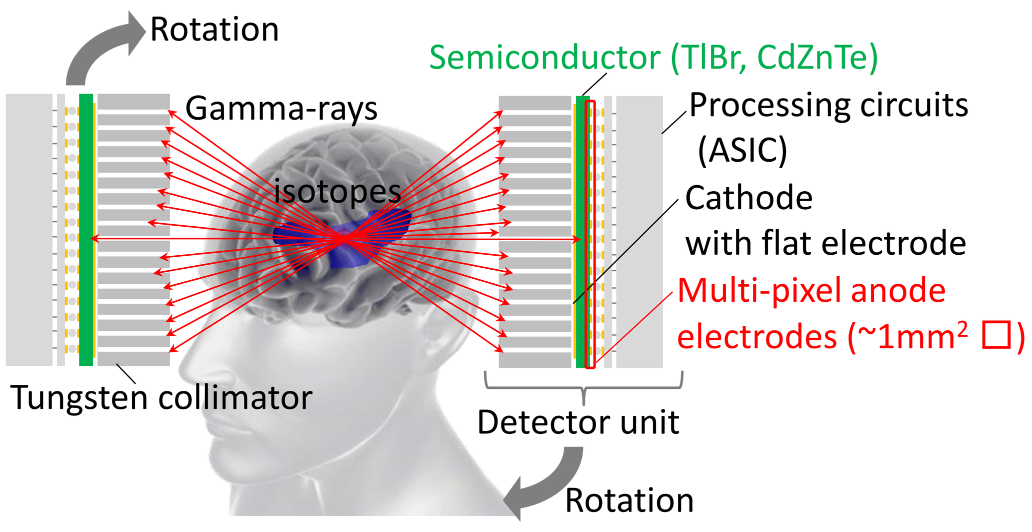


Fig.3. Schematic of SPECT diagnosis.

Advantage of TlBr for SPECT

Due to high atomic number and high density, TlBr has higher absorption than CdZnTe or NaI for high energy gamma-rays from the isotopes used in SPECT.

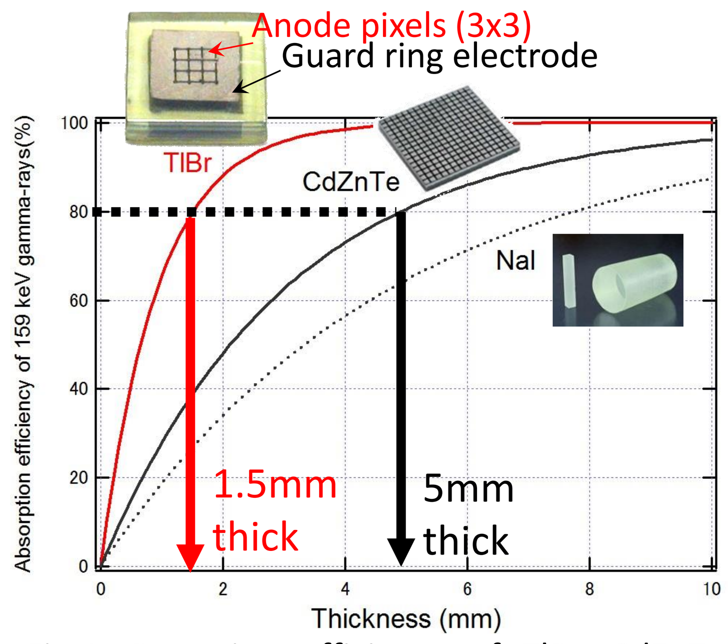


Fig.4. Detection efficiency of TlBr, CdZnTe and NaI for gamma-rays (^{123}I, 159 keV) used in SPECT diagnosis.

High special resolution SPECT

■Anodes:
Small pixel (<1 mm² □) and narrow gap (<0.1 mm).

■Collimator:
Small diameter and narrow gap.

Present electrode formation for TlBr detectors

Vacuum evaporation with a metal mask

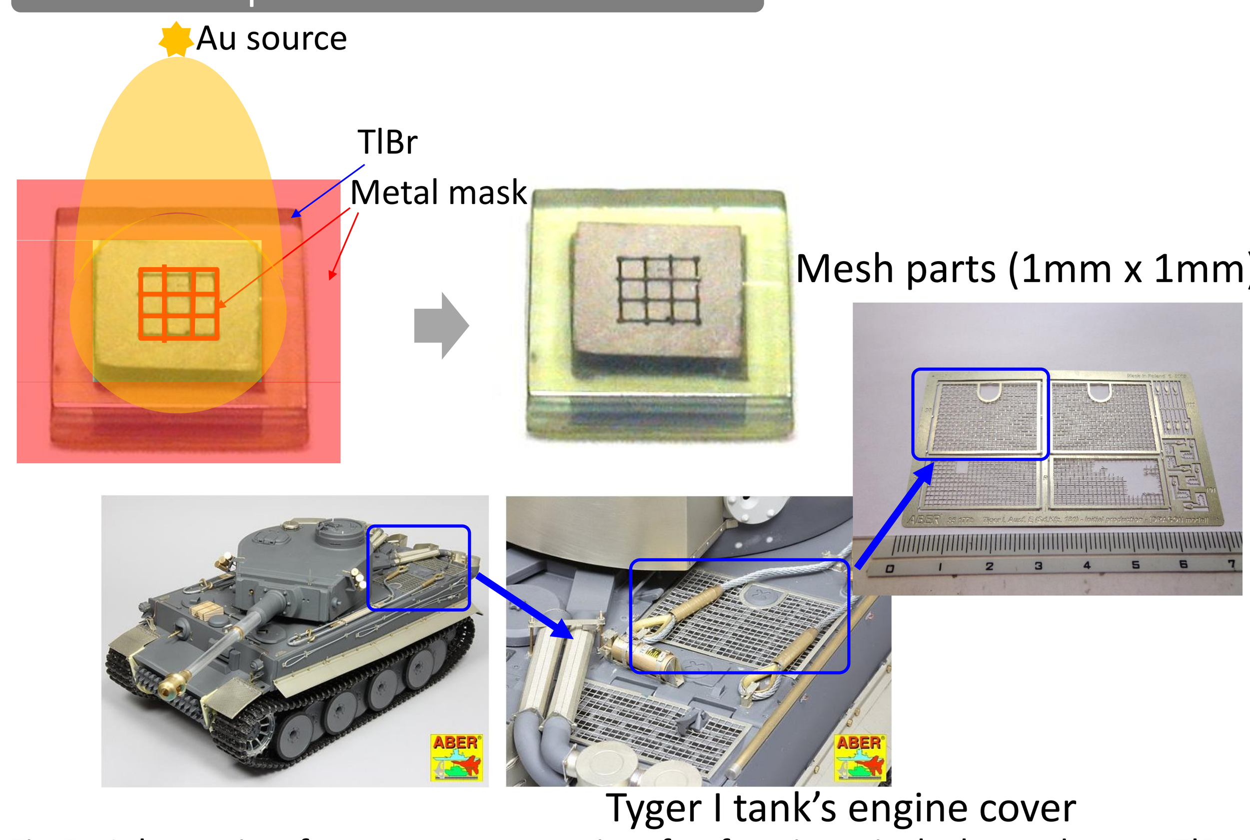


Fig.5. Schematic of vacuum evaporation for forming pixel electrodes on TlBr detectors in our labratory.

- Unsuitable method for mass production in factory !
- Forming fine electrode structure by using metal mask is difficult.

Challenge

Photoresist technique has been used for mask construction on semiconductor wafer in typical production process. Forming masks on TlBr crystals by a lift-off photoresist technique was carried out for the first time challenge.

Photoresist procedure

Pre-coating

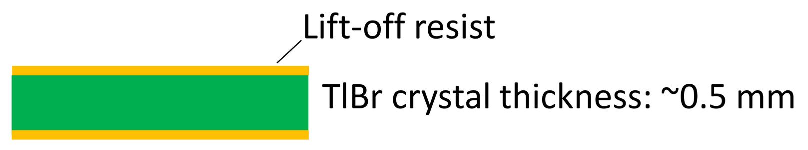
- TlBr crystals (Thickness: ~0.5 mm)
- HMDS
- Spine coater: 500 rpm 5s → 1,000 rpm 30s
- Baking: 100 ◦C, 2min.

Resist coat

- Lift-off photoresist: NPR9730(Nagase ChemteX Corporation)
- Spine coater: 500 rpm 5s → 3,000 rpm 30s

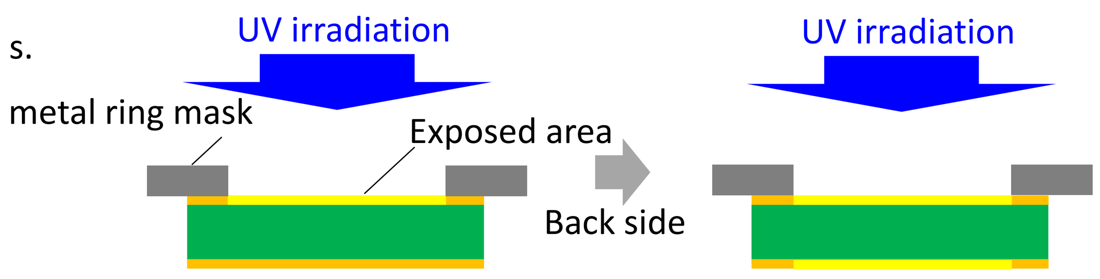
Pre-baking

- 100 ◦C, 5min.



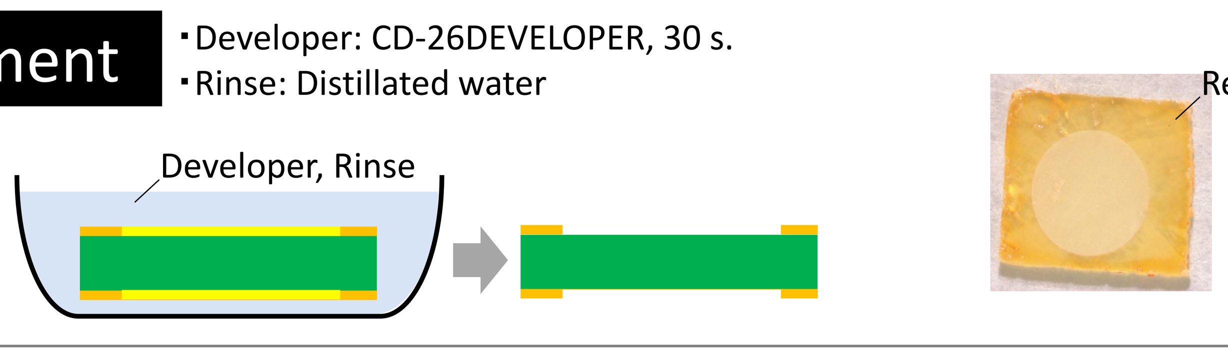
UV irradiation

- 180 s.

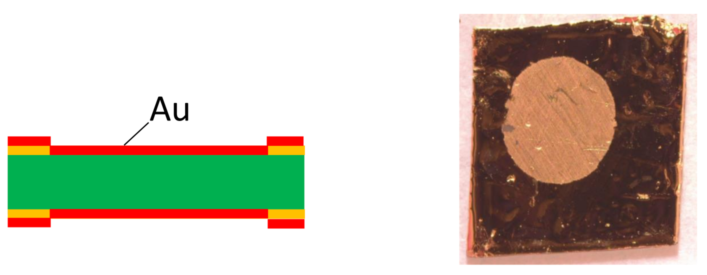


Development

- Developer: CD-26DEVELOPER, 30 s.
- Rinse: Distillated water

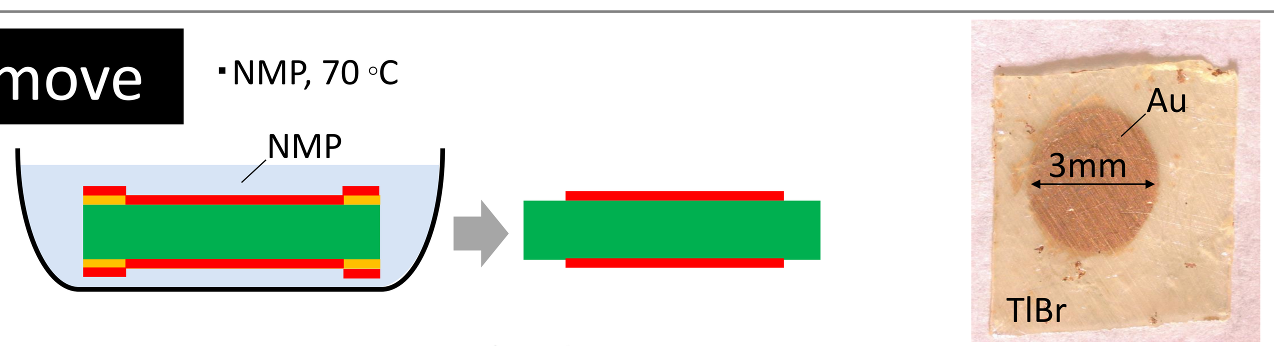


Au evaporation



Resist remove

- NMP, 70 ◦C



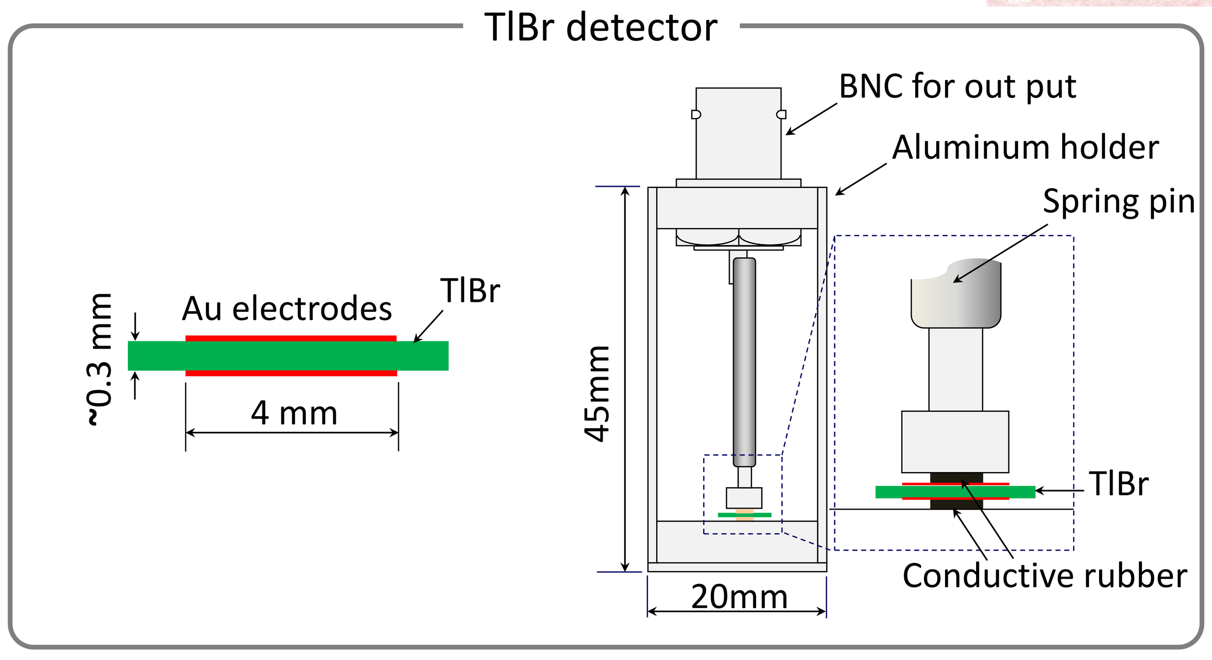


Fig.6. Photoresist and electrode formation procedure for TlBr detector fabrication and schematic of TlBr detectors.

Evaluations

I-V characteristics and resistivity

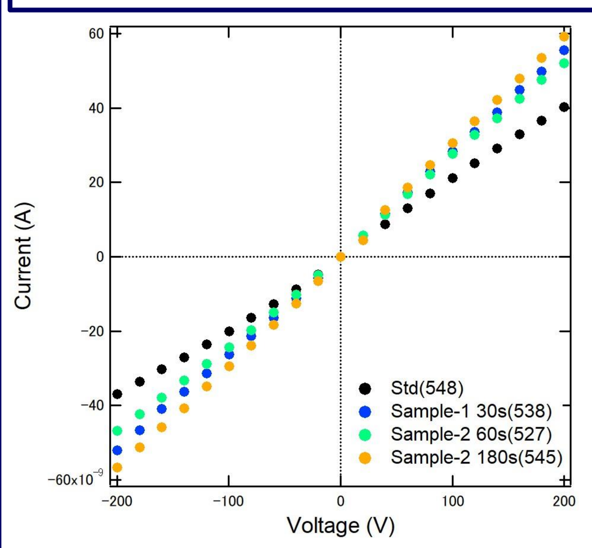


Fig. 7. I-V curves of TlBr detectors with Au electrodes formed by standard procedures and photoresist (irradiation time: 30,60,180 s).

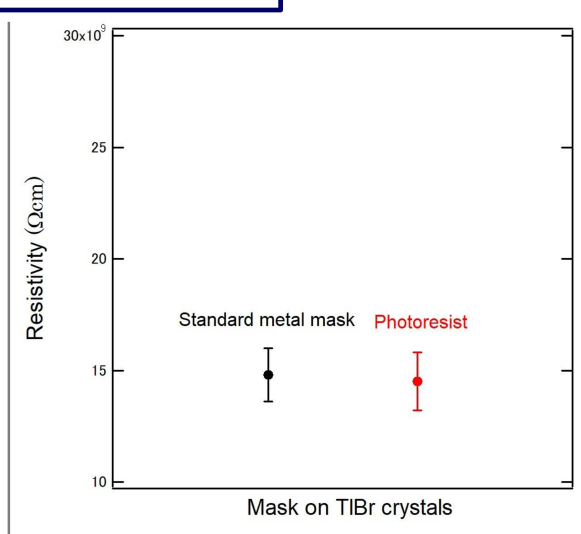


Fig. 8. Resistivity of TlBr detectors with Au electrodes formed by standard procedures and photoresist.

TlBr detectors fabricated by the lift-off photoresist procedure showed ohmic characteristics same as a TlBr detector fabricated by the previous standard process using metal mask. Resistivity of TlBr detectors made by both procedure calculated from the curves were equivalent. These results mean that the photoresist on the TlBr crystals completely removed and optimum electric contact were formed between Au electrodes and TlBr crystal surface.

Charge transport properties ($\mu\tau$ products)

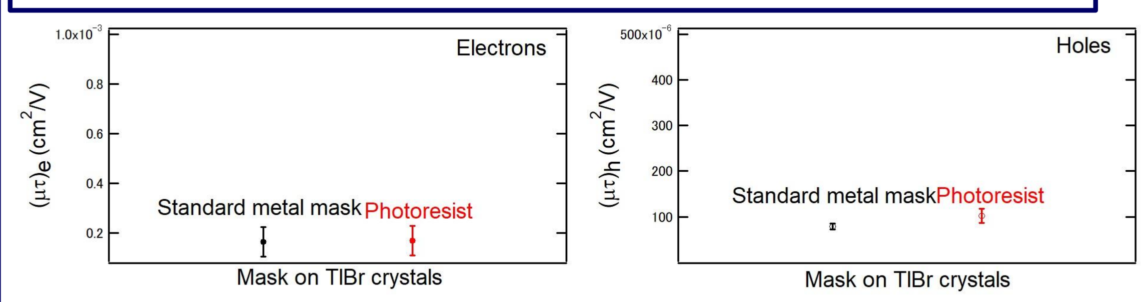


Fig. 9. $\mu\tau$ products of TlBr detectors fabricated by the lift-off photoresist and a standard metal mask.

Fig. 9 shows $\mu\tau$ products for electrons and holes in TlBr detectors evaluated by a conventional system and Hecht equation. The results shows the photoresist procedure cause no degradation to charge transport in TlBr crystals.

^{109}Cd energy spectra

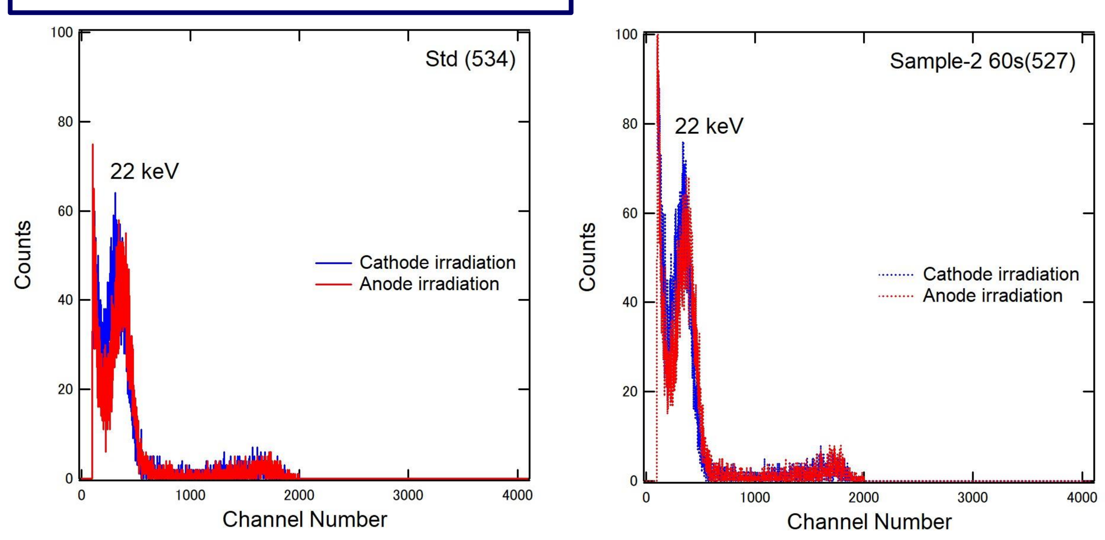


Fig. 10. ^{109}Cd energy spectra obtained from a TlBr detectors fabricated by the standard and photoresist procedure.

Fig. 10 shows energy spectra obtained from TlBr detectors irradiating with a ^{109}Cd source at room temperature. Applied electric field was around 1,000 V/cm and amplifier shaping time was 31.5 µs. An energy resolution exhibited from both TlBr detectors and photo-peak position of 22 keV X-ray from the source were almost equivalent.

Conclusions

○ The results mean that the detector fabrication procedure by the lift-off photoresist in this study is promising procedure for electrode formation on TlBr detectors used for X- and gamma-ray spectroscopy with fine pitch electrodes.

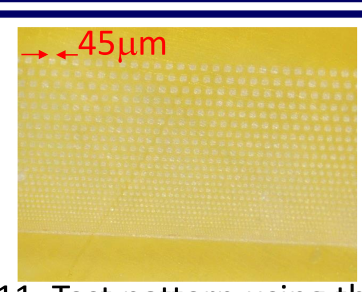


Fig. 11. Test pattern using the lift-off photoresist on a TlBr crystal.

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