RAD 11-27

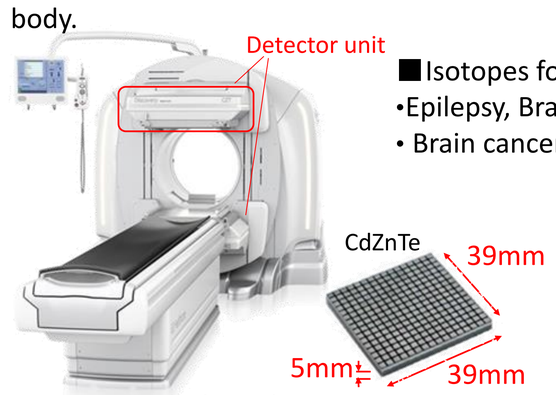
Crystal evaluation and gamma-ray detection performance of press mold thallium bromide semiconductors

Toshiyuki Onodera[1] and Keitaro Hitomi[2]
Tohoku Institute of Technology[1], JAPAN and Tohoku University[2], JAPAN t_onodera@tohtech.ac.jp

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.



■Isotopes for SPECT:
•Epilepsy, Brain infarction and Dementia (^{123}I)
• Brain cancer (^{201m}Tc)

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

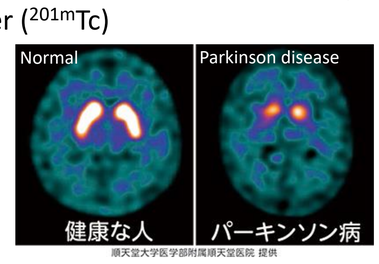


Fig.2. Brain diagnosis images.

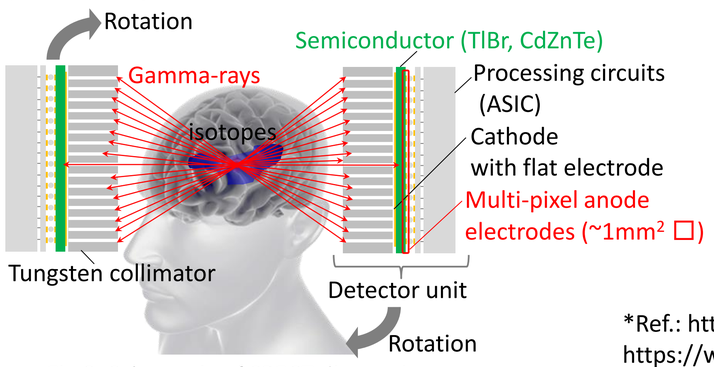


Fig.3. Schematic of SPECT diagnosis.

*Ref.: https://www.crystran.co.uk/
https://www.surfacenet.de/
https://monozukuri.sqcd-aid.com/

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.

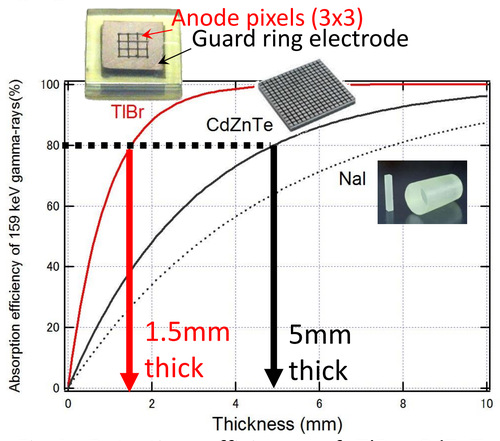


Fig.4. Detection efficiency of TlBr, CdZnTe and NaI for gamma-rays (^{123}I, 159 keV) used in SPECT diagnosis.

Hardness for TlBr crystals

TlBr is seems to be plastic nature and easy to change their shapes by low pressure.

Table 1. Material hardness for TlBr, CdTe and common examples.

Material	*Knoop hardness (kg/mm²)	Examples
TlBr	**12**	Nail, Lead
CdTe	54	
Quarltz	820	

Detector fabrication procedure

Previous procedure

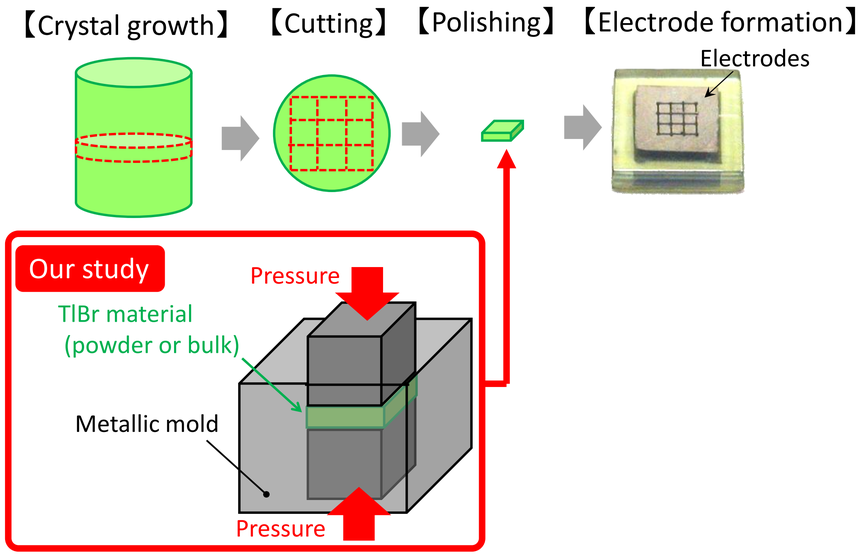


Fig.5. Fabrication procedure for typical semiconductor detectors and new fabrication method performed in our laboratory.

- TlBr crystal ingots are necessary for flat detector production in the typical semiconductor device procedure.
- TlBr bulk crystals with flat panel shape may be easily formed by the press mold technique.

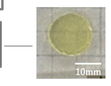
Challenge

TlBr gamma-ray detectors have been fabricated from TlBr bulk materials made by the press mold technique, and their crystallinity and device characterization were evaluated.

Press mold technique

TlBr powder
→ Zone refining method
→ Forming ingots using purified TlBr

→ Cutting(17mmϕ x 5mm)
→ Chemical etching



→ Press mold (455 ℃, 50kN, Ar)

Fig.6. Experiment procedure.

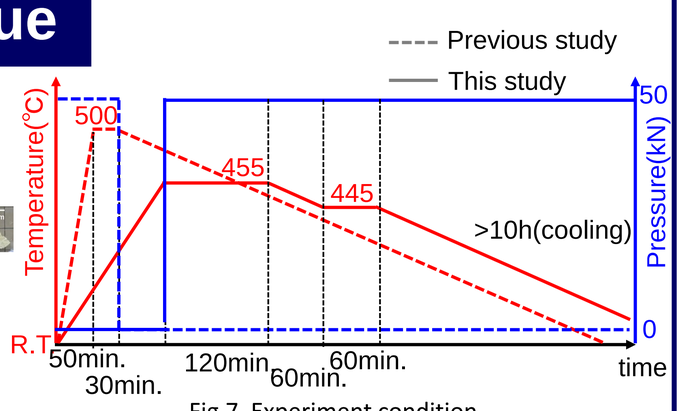


Fig.7. Experiment condition.

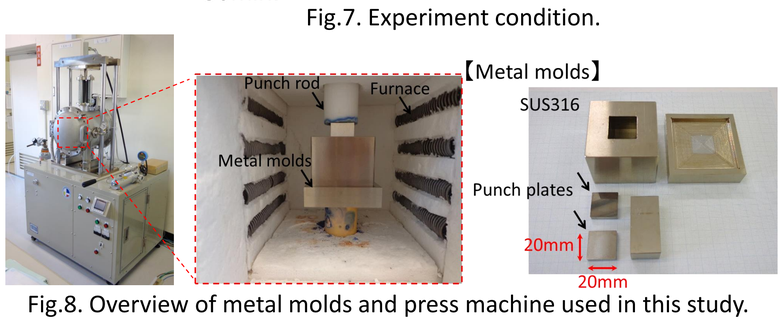


Fig.8. Overview of metal molds and press machine used in this study.

Evaluations

X-ray diffraction and EBSD

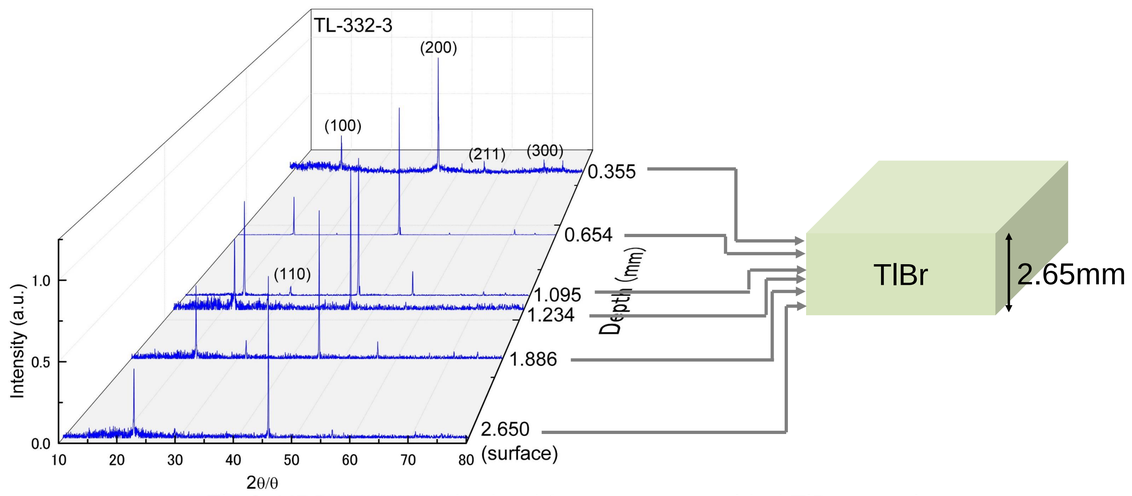
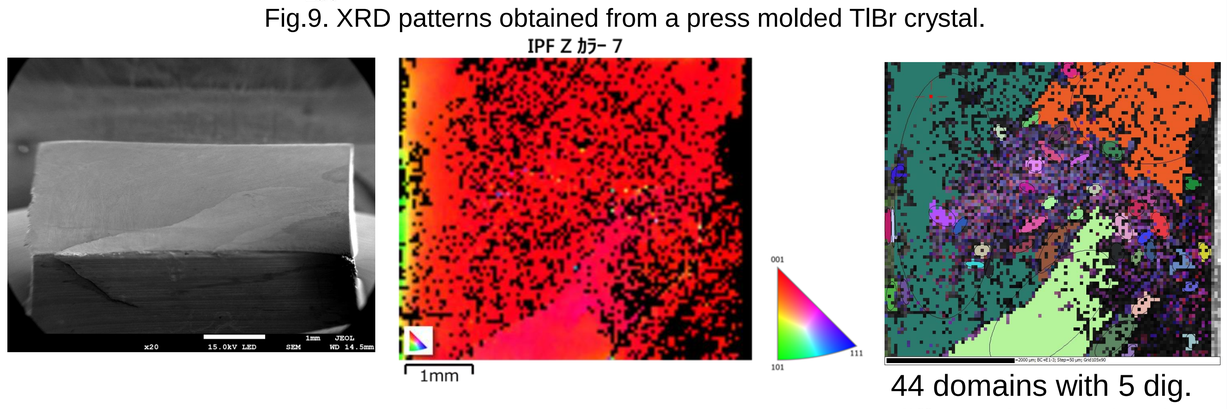


Fig.9. XRD patterns obtained from a press molded TlBr crystal.

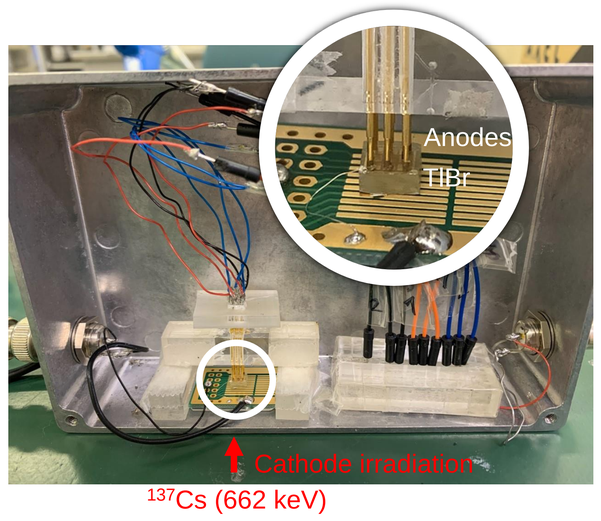


44 domains with 5 dig. differencies each other.

Fig.10. SEM image and EBSD pattens.of a molded TlBr crystal.

Gamma-ray detectors

Pixelated TlBr detectors



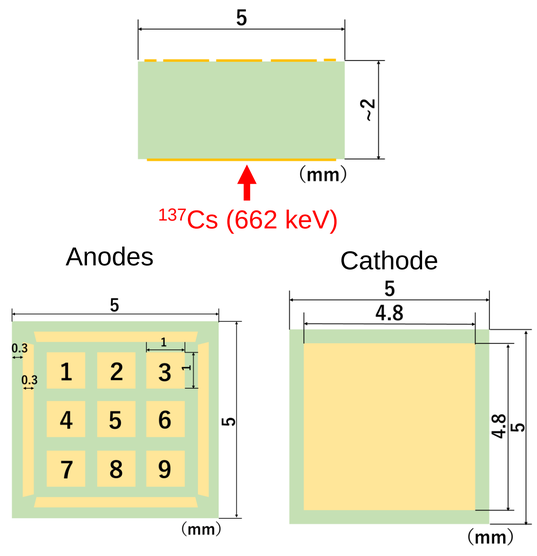


Fig. 11. Pixelated TlBr detectors fabricated from a molded TlBr crystals and electrodes structure.

^{137}Cs energy spectra

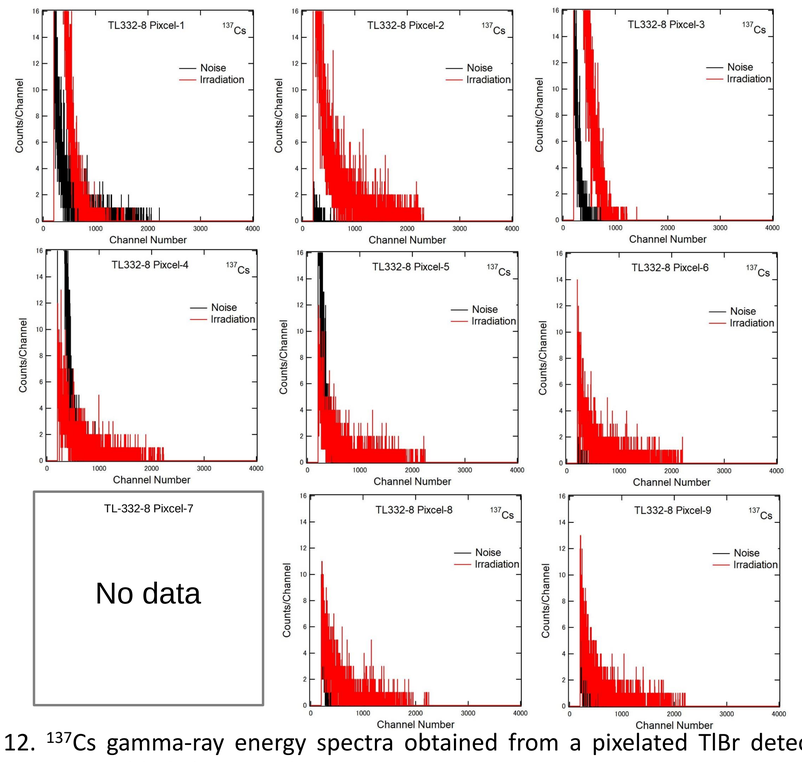


Fig. 12. ^{137}Cs gamma-ray energy spectra obtained from a pixelated TlBr detector fabricated from a press molded TlBr crystals.

Conclusions

◯TlBr crystals were molded by the hot press techniques using purified TlBr materials.
◯Pixelated TlBr detectors with 3 x 3 anode electrodes were fabricated from press molded TlBr crystals and was successfully responded by gamma-ray irradiation.

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