Spatial Resolution of X-ray Imaging using 80µm pitch TlBr Detector

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Introduction

TlBr detectors are suitable for X-ray imaging applications:

- large attenuation coefficients (high atomic numbers, high density)
- higher resolution than scintillator type detector because TlBr detector can directly convert X-ray photons into electron-hole pairs.

This study introduces an X-ray imager that uses TlBr detectors and demonstrates its potential for X-ray imaging applications.

We researched pixelated TlBr detector behavior:

- Spatial Resolution
- Stability over time

Structure of Imager

TlBr detector is stacked on the ROIC using silver-paste bumps.
The detector is equipped with a thallium electrode as well as pixelated silver electrodes. (Fig.1)

TlBr crystal size is 3.2mm x 3.2mm, pixel count is 40x40. (Table1)

Experiment Result

Spatial Resolution:

Fig. 2 depicts the imaging result and the column-averaged line profile of an X-ray test chart that includes various line-pairs.
MTF were fitted to 180µm sampling, denoted by a dashed line.(Fig.3)

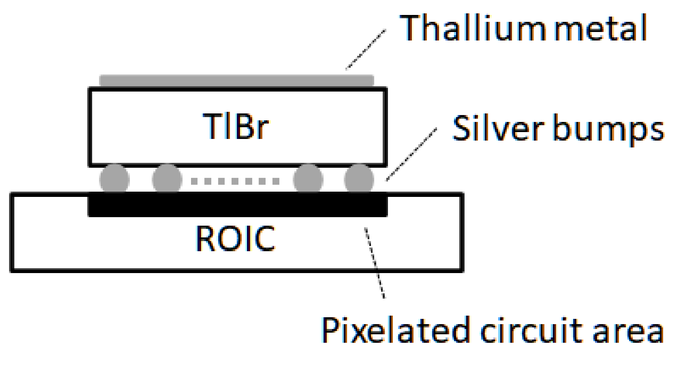
Stability over time:

Lower half area of detector is shielded by copper plate.
switch the collection mode every 10 minutes in order to suppress the deterioration of image quality due to the polarization phenomenon.(Fig.4)
In hole collection, Image quality deteriorated significantly after 60 minutes.
Electronic collection maintained good contrast until after 200 minutes.
However, the pixel-by-pixel uniformity was deteriorated.

Conclusion

1. The measured MTF is sufficient result considering that the imager was not designed specifically for the TlBr detector.
2. In the short-time switching of the collection mode, the image quality deteriorated after 1 hour or more of operation.
3. It suggests that the electrode structure needs to be improved for long-term stability of operation.

TlBr detector has achieved high resolution and is promising as an X-ray imager.
The results can motivate the development of pixelated small electrodes with the suppression of the polarization phenomenon, ROIC design, and stacking processes for TlBr detectors.



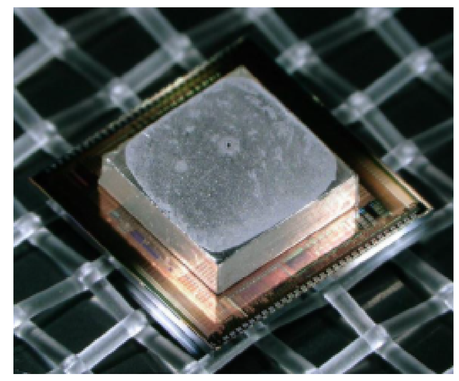


Fig. 1. Structure of the assembled TlBr X-ray imager (left) and the structure after stacking (right)

Table. 1. specification of TlBr X-ray imager

Detector size	3.2mm x 3.2mm x 0.8mm
No. of pixels	40 x 40
Pixel pitch	80µm
Plate electrode	Thallium
Pixelated electrode	Silver
ROIC type	Photon-counting
Readout polarity	Both

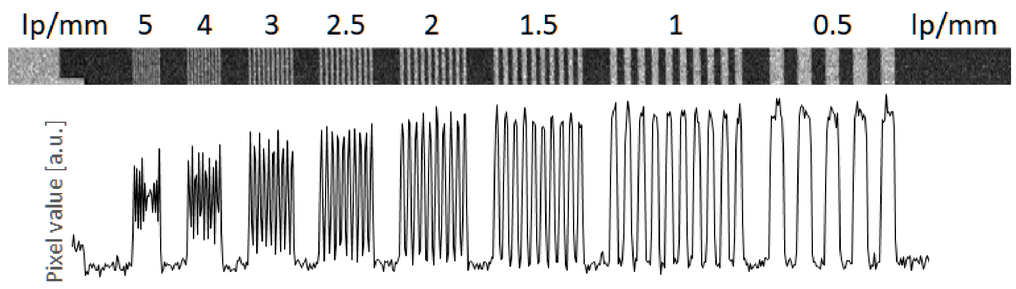


Fig. 2. Imaging result of an X-ray test chart that includes 0.5–5 lp/mm line pairs. The bottom graph shows the averaged line profile

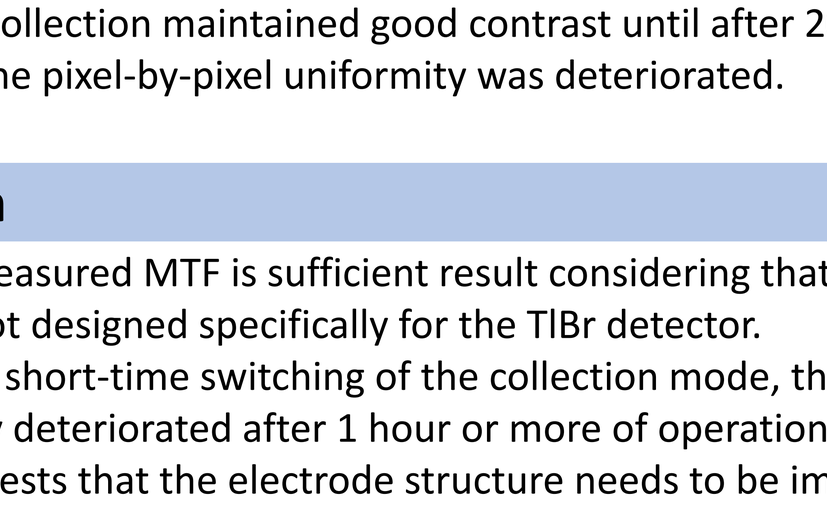


Fig. 3. Calculated MTF based on the X-ray test chart results. The solid line denotes the sinc function corresponding to an MTF of 80µm sampling, the cross-marks denote the measured MTF of the proposed imager, and the dashed line denotes the sinc function corresponding to an MTF of 180µm sampling

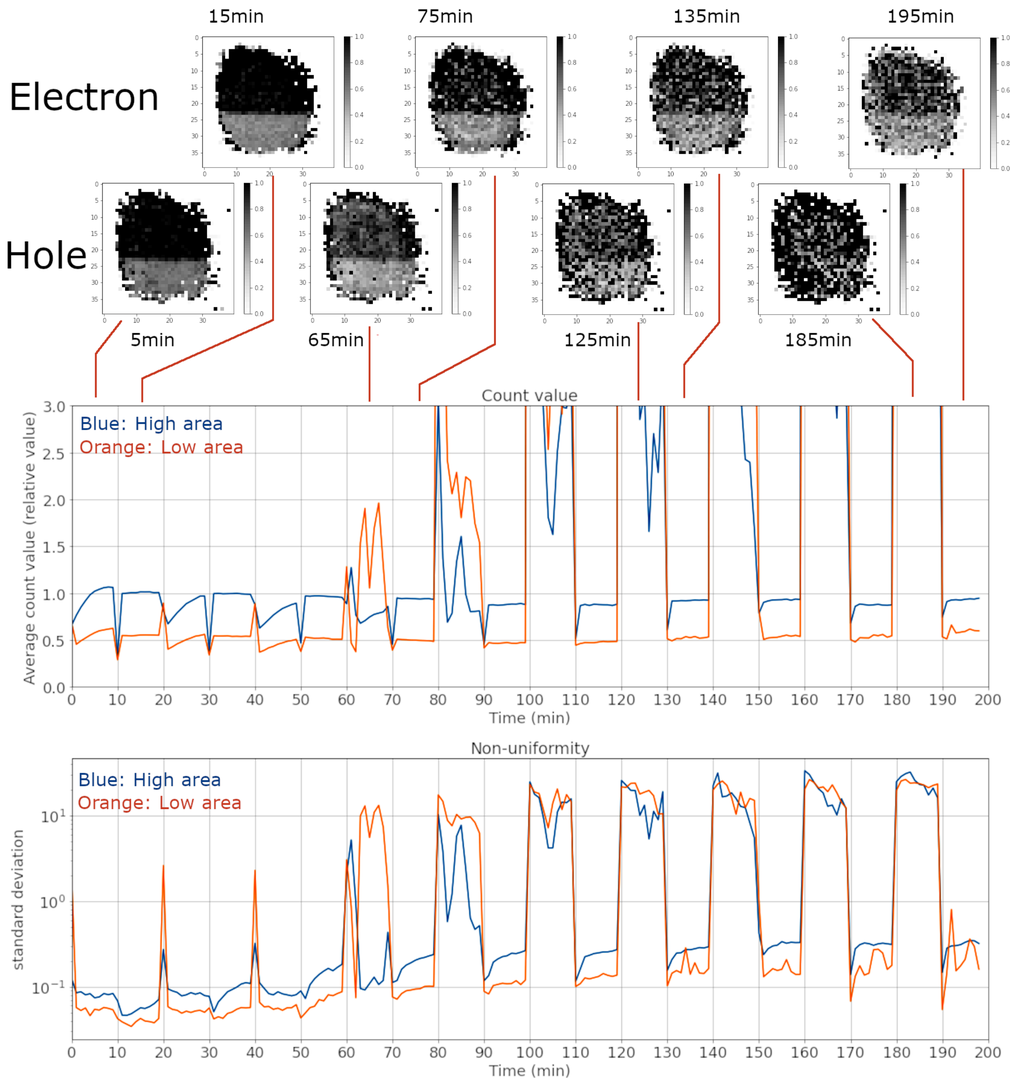


Fig. 4. The upper graph shows the change over time in the count value. The bottom graph shows the standard deviation of the counts per pixel. Larger values indicate poor pixel-by-pixel uniformity. The blue line is the unshielded area and the orange line is the shielded area.