Exploring the use of Thallium Bromide Semiconductor Detectors for Security Applications

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Thallium Bromide

Thallium Bromide is a dense, wide band gap (2.68eV) compound semiconductor, which allows for room temperature operation, and gives it a greater attenuation coefficient than currently popular CZT crystals. It also has a large resistivity at room temperature, minimising electronic noise, and a low melting point, allowing for simplistic production methods [1]. These properties have made TlBr extremely promising for use in gamma ray and X-ray detection, specifically in modern security systems.

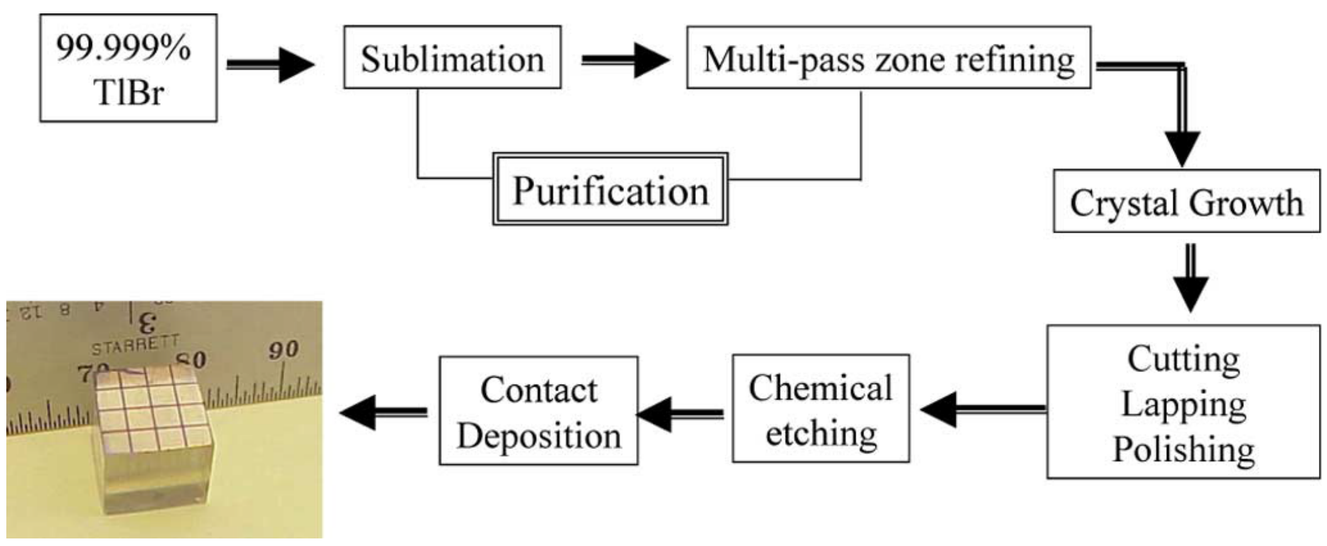

Figure 1. Diagram of steps taken to fabricate a TlBr Crystal [1].

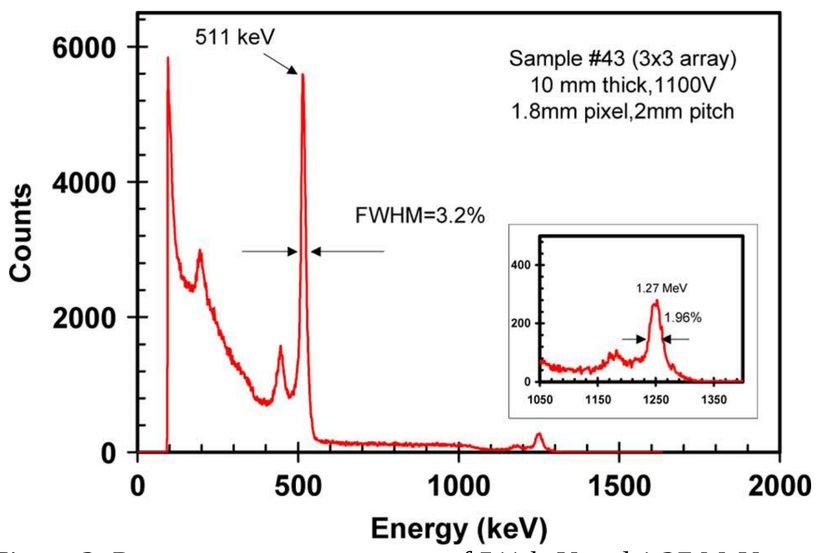

Figure 2. Room temperature spectra of 511 keV and 1.27 MeV gamma rays from one pixel of 10 mm thick TlBr detector.[1].

Research

CapeSym supplied us with two 5x5x30mm crystals, with Palladium contacts, to be used to construct the detector. Currently there has been no research on crystals of this size, however H. Kim et al achieved impressive initial results on a 10x10x10mm array, with energy resolutions of 5.5% and 2.5% for 122keV and 662keV peaks respectively [1]. The main challenges of working with TlBr are its long charge collection times; soft, malleable structure; and migration of the Br^- ions under long bias, which degrades the anode material.

The Project

The University of Liverpool was approached by Rapiscan, a global security company, to help fabricate a TlBr detector to be deployed in their cargo and vehicle inspection systems. There are two sets of aims for the development of TlBr in this project:

Gamma-ray Counting;

- Testing the optimum position of contacts
- Building the necessary electronics to run the detector
- Finding the best operating voltages and set up parameters for a 30mm crystal
- Measuring the energy resolution and efficiency, and comparing to current CZT detectors

X-ray performance:

- Testing imaging capabilities
- Analysing penetration performance
- Setting up coincidence measurements

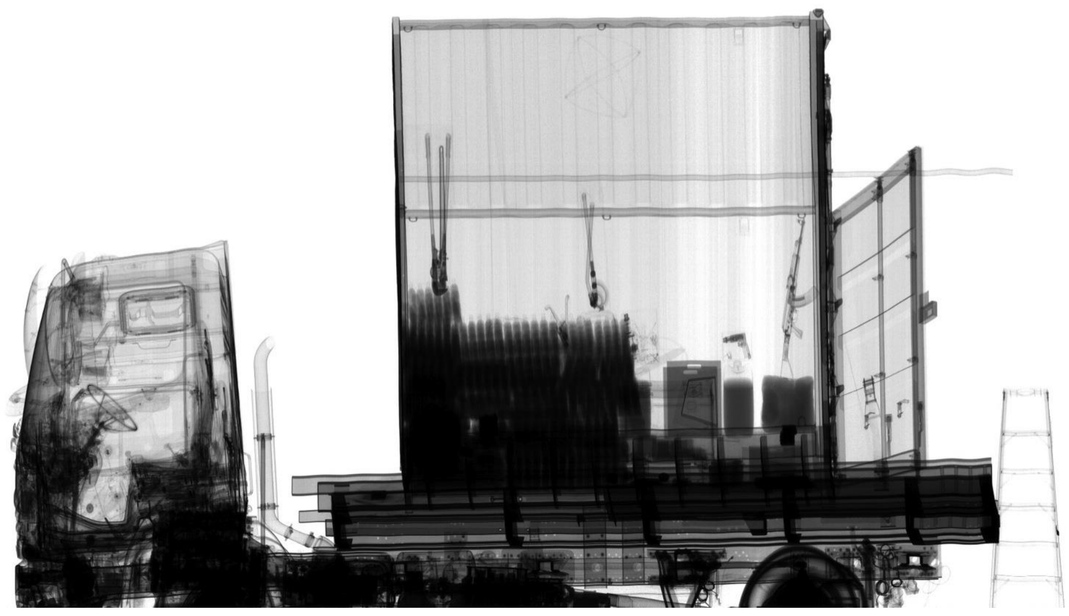

Figure 3. An X-ray scan of a truck[2]. Resolution is poor, and can't distinguish between some items inside the truck. It is hoped the use of TlBr crystals will increase the detector resolution.

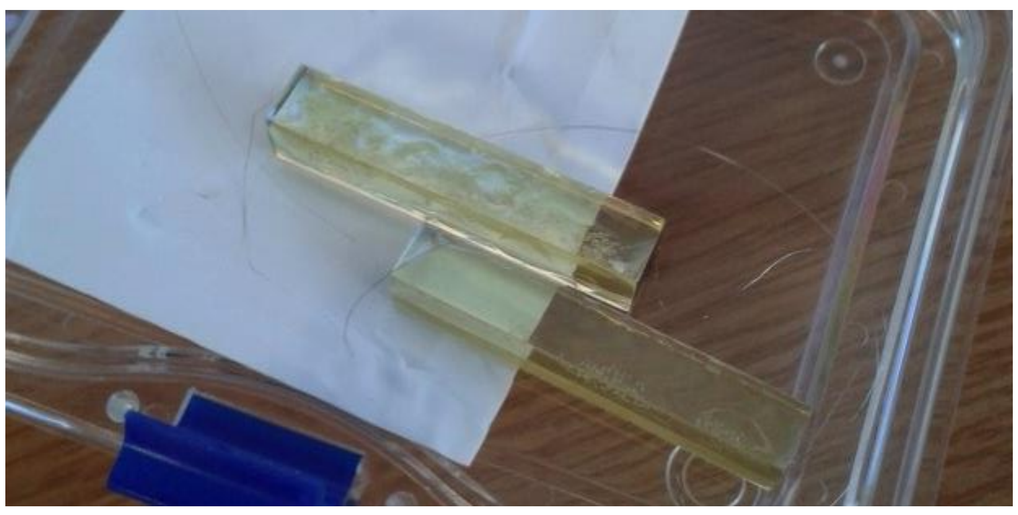

Figure 4. The two crystals supplied by CapeSym, with thin Palladium contacts visible.

Current Status

One of the crystals is in the process of being cut into smaller (5mm, 10mm) sizes. This would allow work to be done on it, to gain an understanding of how to handle the crystal and gain familiarity using it, before using the full 30mm crystal to fabricate a detector. This approach will extend the duration of the project, but should let us eventually design the full size detector a lot faster, and with fewer errors.

[1] Developing Larger TlBr Detectors—Detector Performance, H.Kim, IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 56, NO. 3, JUNE 2009.
[2] Image supplied by Rapiscan