Thermomigration of Tellurium Inclusions in CZT

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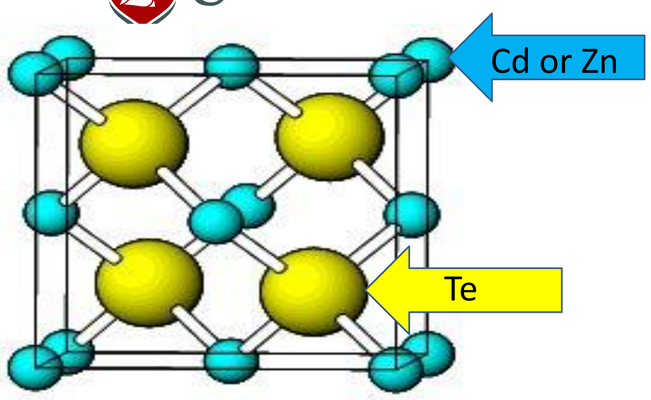
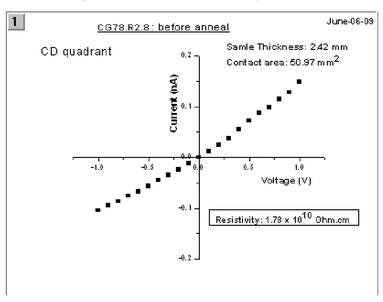


Cadmium Zinc Telluride (CZT) is a room temperature semiconductor. It functions as a radiation detector for x-rays and gamma rays. It also has applications in photovoltaics and as a substrate material.

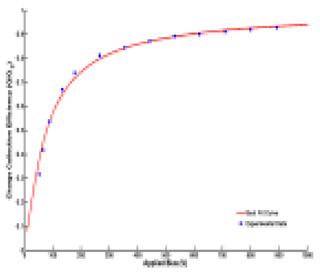
To make a good detector:

Good stuff:

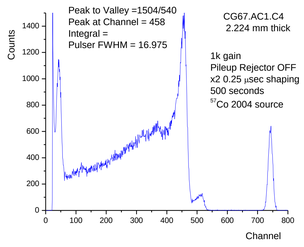
High resistivity



High μτ product

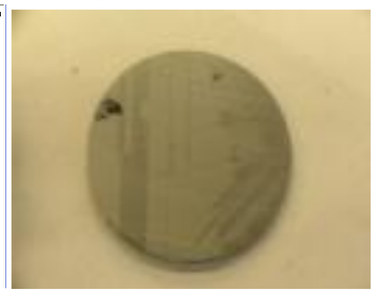


High Resolution

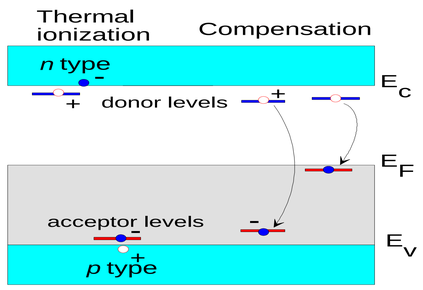


Bad stuff:

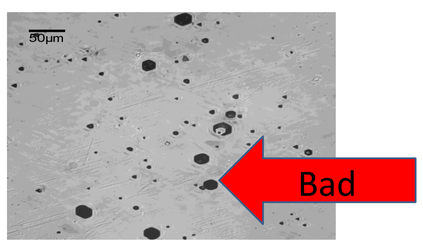
Crystal defects



Impurities



Tellurium Inclusions



CZT is transparent in the infra-red, but the inclusions are not, so they show up well in an IR transmission microscope.

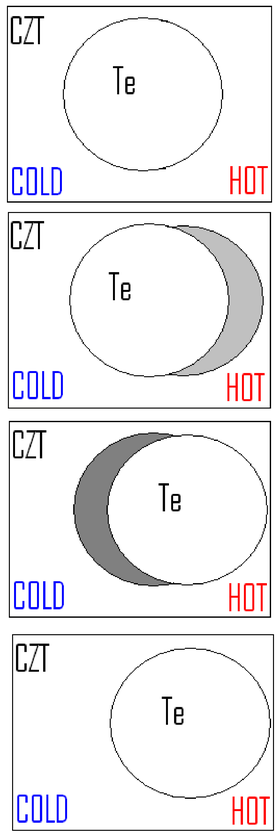
Tellurium inclusions:

When growing CZT, excess tellurium will accumulate inside the crystal. These small secondary phases will trap electrons and reduce the effectiveness of the detector. But all is not lost! There are ways to remove inclusions.

Thermomigration:

Inclusions will move along the thermal gradient, moving from cold towards hot. This effect is called thermomigration, and can be used to drive these imperfections out of the crystal. This should work even for large crystals, as opposed to only thin wafers as with other methods.

How Thermomigration Works



A tellurium inclusion resides in the CZT matrix.

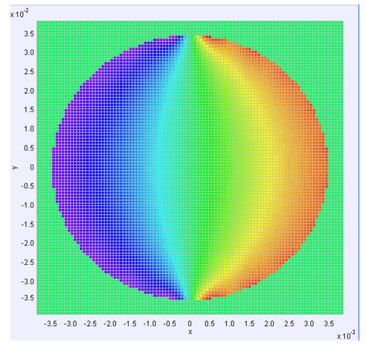
A little bit of CZT dissolves on the hotter side of the inclusion.

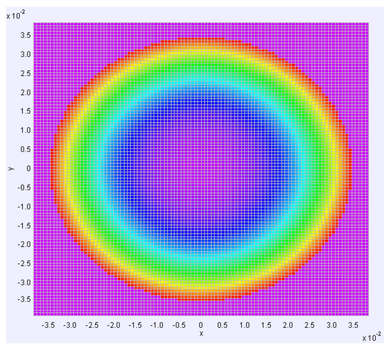
The CZT redeposits down on the colder side of the inclusion

The inclusion has moved a little bit!

Heating Schemes:

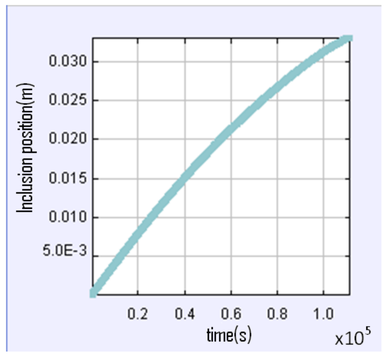
I simulated steady-state lateral heating (left) and pulsed radial heating(right). Pulsed heating is time dependent. This would provide a way to remove inclusions during growth (rather than in post-processing). In radial heating, the ingot is heated quickly (to produce large thermal gradients) and cooled slowly (to minimize the effect of the backward gradients).

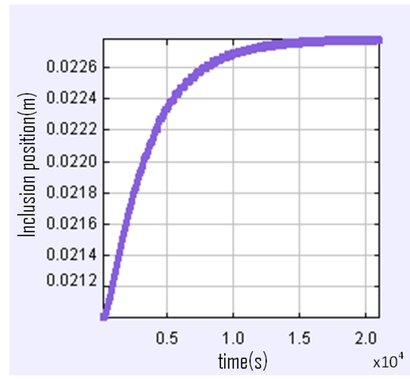




Simulation results:

The radial pulsed heating still needs to have the cycle optimized. Inclusion migration is slow. In simulation, the lateral heating performed well.





Conclusions:

Radial heating could work, but takes a long time. Lateral heating should works as expected. Experimental confirmation is needed for both techniques.

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