Optical and electrical characterization of Cadmium Telluride (CdTe) X-ray pad detectors

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Alex Winkler

Thursday, December 14th, 2017, Session 12 – 4, ID 173
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Particle Physics to the people
Particle Physics to the people

• CMS pixel upgrade work
• Detector research for HL-LHC and other detector applications
• Emphasize efforts of developing detectors for medical imaging
  • Use HEP developments + effective detector materials
  • Ultra low dose imaging
  • BNCT

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Particle Physics to the people

• Medical imaging want same thing as HEP:
  • Faster, smaller detectors
  • More pixels
  • Higher bandwidth
  • More information = spectrum/ pixel (photon counting)
  • Radiation hardness
Particle Physics to the people

Detectors need to work:
• Efficient = high stopping power (calorimeter) → Si out
• RT operation → Ge out
• Large volumes/ bulk detectors → GaAs out
• CdTe/ CdZnTe (CZT)
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- CdTe/ CdZnTe (CZT)
  - High \(Z_{\text{eff}}\) = 50
  - Large bandgap \(\rightarrow\) RT operation
  - High resistivity \((10^9 - 1.5 \times 10^{10} \, \Omega\text{cm})\) \(\rightarrow\) several cm thick detectors possible
  - Reasonably developed

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CdTe/ CZT, but?

- ... is not Si!
  - Brittle, toxic
  - Chip scale processing
  - Not temperature stable (processing < 140°C)
  - Not every chemical works

Details in Ms. Gädda’s poster (P21) and PSD11 proceedings.
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  • Precipitates
    → Act like deep level defects
    → Reduce CCE and $E_{res}$

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DOI: 10.1109/TNS.2002.803882
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Precipitates as key

• Precipitates dictate detector performance
  • Number
  • Size
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• Need to predict detector performance before production
• HOW?
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• HOW?
  → IR microscope mapping
IR mapping
IR mapping

FIG. 3. IR microscope images of CZT1 at 10× magnification.

FIG. 5. Histogram of the Te inclusion size distribution in CZT1 and CZT2.

Adapted from Tepper et al. DOI: 10.1063/1.2967726
3D IR characterization (HIP)

• 3D IR microscope
• High resolution ($\approx 210/170 \, \mu m$)
• Precipitates close to diffraction limit $\approx 1\mu m$
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- High resolution ($\approx 210/170$ $\mu$m)
- Precipitates close to diffraction limit $\approx 1\mu$m
- 2/3D maps of precipitates distribution
3D IR characterization (HIP)

• Scanned a few hundred crystals
• Confirm Tepper results: smaller precipitates more present
• In CdTe most precipitates are <5 µm size

FIG. 5. Histogram of the Te inclusion size distribution in CZT1 and CZT2.
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11TH INTERNATIONAL CONFERENCE ON POSITION SENSITIVE DETECTORS
3–8 SEPTEMBER 2017
THE OPEN UNIVERSITY, WALTON HALL, MILTON KEYNES, U.K.

Advanced processing of CdTe pixel radiation detectors

CdTe pad detector
Detail in Ms. Gäddä’s poster and PSD 11 proceedings.
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Conclusions & Outlook

- TCT: CCE is strongly location dependent
- IR: correlation of CCE map and defect map
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- Based on defect map $\rightarrow$ "panel mosaic"