Medipix 2: Processing and measurements of GaAs pixel detectors
M. Fiederle
A. Fauler, A. Zwerger
Freiburger Materialforschungszentrum
SG Material Characterization & Detector Technology
Albert-Ludwigs-Universität Freiburg
www.fmf.uni-freiburg.de
Outline
• Processing of pixel detectors
• GaAs – for detector applications (revival)
• Measurements with GaAs Medipix assemblies
• Comparison with Silicon assembly
• Summary and outlook
Medipix Activities Freiburg

• Development and characterization of detector material: GaAs, CdZnTe

• Processing of pixel detectors: Flip-chip bonding

• Evaluation of detector assemblies: X- and Gamma-rays, …
Processing of pixel detectors (FMF)

- pixels sizes down to 55 µm (pixel Medipix2)
- 4000 - 65,000 pixels
- Low temperature processing (< 200 °C)
- Polymere passivation (BCB)
- Low force Flip-Chip-Bonding
- Processing of single detectors or wafers
Detector assembly after flip-chip process
CdTe – pixel detector Medipix1
Medipix 2: Processing features

Pixel size on the detector side can be increased (110x110µm², 165x165µm², ...) bonding only 1 out of 4 / 9 /... pixels on the MP2 chip

55x55µm² every MP2 pixel used

110x110µm² every 4th MP2 pixel used
GaAs pixel detectors
(LEC material from commercial supplier)

- @ 40keV:
  - Si: 7.5%
  - GaAs: 55%
  - CdTe: 100%

- @ 60keV:
  - Si: 2.2%
  - GaAs: 22%
  - CdTe: 90%
Properties of GaAs radiation detectors

- Semi-insulating material
- Available technology
- Good absorption (< 50 keV)
- Wafer sizes available up to 6 inch
- 55 µm resolution possible (small effect of fluorescence)

Strong development over the last 5 years:
- Reduction of defect concentration (EL2)

Performance is depending on bulk properties
GaAs 1x1 assembly processed and bonded at FMF
Detector bias at 270V \( I = 50\mu A \)

Am-source
Detector bias at 275V I = 400µA

Am-source

High leakage current
Detector bias at 275V I = 50µA

x-ray tube
Detector bias at 280V $I = 300\mu$A

x-ray tube

High leakage current
Cell structure at low bias
GaAs 55x55μm² detector
GaAs 110x110µm² detector

dose: 90µGy (W 60kV 7mA 1.5mm Al 30ms)
Flatfield acquisition (W 60kV, 1.5mm Al) without correction, only th.adj.mask is activated

270V
Flatfield acquisition (W 60kV, 1.5mm Al)

without correction, only th.adj.mask is activated

190V
X-ray images of TTL-chips

GaAs 55x55µm²

GaAs 110x110µm²
MTF comparison GaAs

MTF determination (edge method)

Nyquist: 4.6 lp/mm

Nyquist: 9.1 lp/mm
GaAs 2x2 detector IV measurement
Energy calibration for 300µm GaAs assembly

- Tb K$_\alpha$ (44.23 keV)
- Ga/As escape
- Ga: 9.2 keV
- As: 10.5 keV
- $^{241}$Am (59.5 keV)
Comparison of integrated counts

same acqu.time

source:

$^{241}\text{Am}$ 59.5keV

Tb K$_\alpha$ 44.2keV

-- : 300µm GaAs

-- : 700µm Si
mean counts per pixel vs. bias (GaAs2x2 detector)
x-ray tube 60kV, 1.5mm Al

counts per pixel

bias voltage (V)

10^2

10^3

10^4

10^5
Advantages of „pixel binning“:

· SNR will be increased

· if unused pixels are switched off, THL can be set to lower values

· pitch can be adapted to application + material and/or thickness

· charge sharing can be reduced

Disadvantages:

· one pixel has to compensate 4/9 times higher leakage current

· lower spatial resolution

· counters are „full“ very quickly → more frequent readout
Conclusion

• Flip-chip-process successful for GaAs
• 55µm and 110 µm pixel detectors
• MTF and absorption (for higher E) are at the theoretical limit
• material not fully depleted
  – processing of 250 µm wafers
  – higher bias (HV passivation)

Research on material properties:
• Comparison of LEC and VGF material

• Processing of QUAD
Thanks for your attention!