Advancing Front-end Readout ASICs with BiCMOS SiGe Technology for Ultra-Fast Sensors

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Research Topic

Development of Advanced Front-end Electronics

For Monolithic and Hybrid Pixel Detectors
- with HVCMOS, SPAD, SiPM and THz sensors
- with high time resolution

For Applications in
- astro-particle physics
- beam diagnostics
- particle physics

Main Focus in Design of
- preamplifier and comparator
- time to digital converter (TDC)
- digital readout

→ mixed-signal ASIC design

Challenges

Developing Pixel Detector ASICs

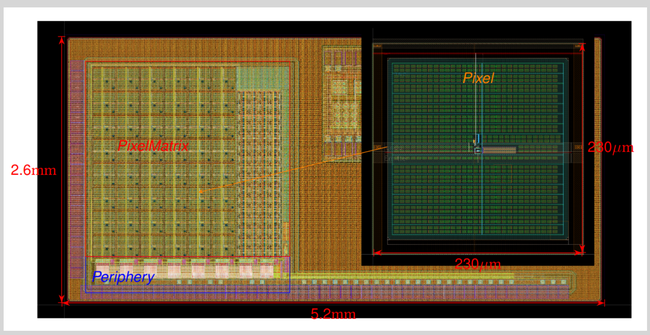
Pixel Detectors with High Time Resolution need
- needs high speed circuits
- low power consumption

Routing and Design Rule Restrictions
- technology-depended
- number of design rules increases dramatically for advanced nodes
- e.g. polysilicon filling rules vs. pixels with small charge collection nodes

Reliability in Difficult Environments
- high radiation in particle detectors
- large temperature variations for surface-based astroparticle detectors

Latest Development

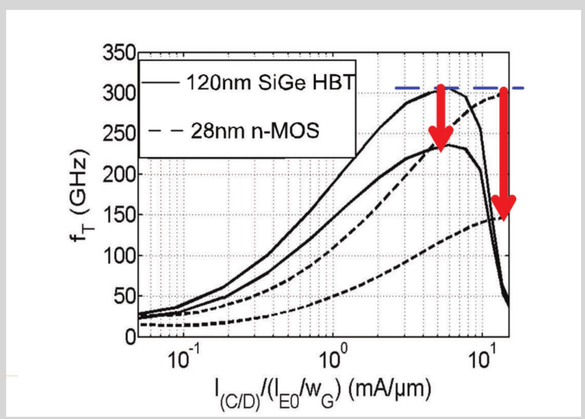
PicoPix1



- High Voltage Monolithic Active Pixel Sensor (HV-MAPS)
- expected time resolution below 100 ps
- two different flavors of pixels
  - large N-well
  - small N-well

A Solution: Heterojunction Bipolar Transistors (HBT)

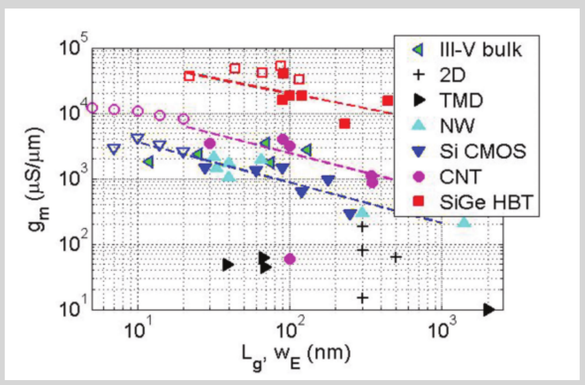
High time resolution requires:
- fast Amplifiers = high f_T



Transit frequency f_T HBT vs. MOSFET [1]

- low noise

Pixelated design requires:
- low area consumption



g_m vs. area of different technologies [1]

- low power consumption

→ HBT offers better performance in analog circuits than CMOS

Our Process:

IHP SG13G2
130 nm SiGe BiCMOS[2]

- IHP is a research institute working closely together with KIT
- IHP offers the SiGe HBTs with highest f_T
  - f_T/f_{max} = 300 GHz/500 GHz
- triple-well process available
- PDK for Cadence Virtuoso design environment
- already used for pixel sensors with high time resolution[3]

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References

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[2] H. Rücker, B. Heinemann and A. Fox, "Half-terahertz sige bicmos technology," in *2012 IEEE 12th Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems*, 2012, pp. 133–136. DOI: 10.1109/SiRF.2012.6160164.

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