Spectral Imaging using Hybrid Integrated, Large-Area High Resolution X-ray Detectors

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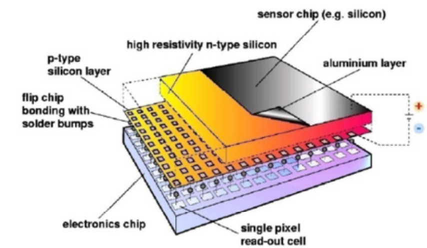
Why Spectral Imaging

In X-ray imaging, e.g. for Medical or Security applications the ultimate image quality is obtained when the energy of *each* incoming photon is measured:

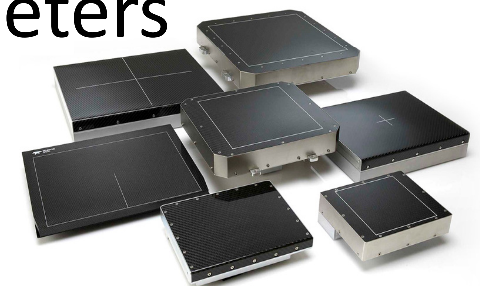
- Increased discrimination between different materials.
- Significantly better image contrast can be achieved.
- Significant enhancement in image quality with reduced radiation dose.
- Reduction of noise for the same quantum efficiency.

State-of-the-Art

Current approaches (like Medipix & Timepix) are a combination of **direct detection** and **ROIC's**

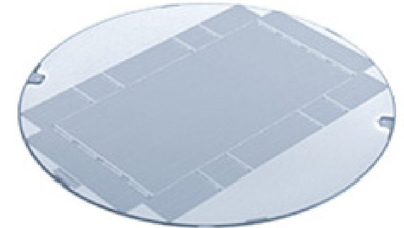


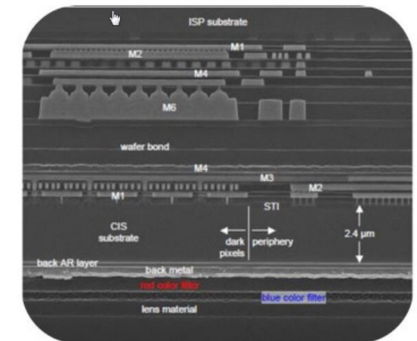
- Disadvantages direct detection
  - Requires high voltages
  - Materials are expensive (medical: CdTe and a-Se) and suffer from degradation
- Image sizes
  - Currently limited to a few square centimeters
  - Commercial Medical X-ray imaging size between 13x13 to 45x45cm^2.



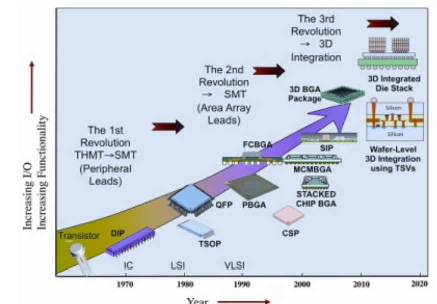
Enablers Spectral Imaging v2

- **Indirect detection**
  - Structured and fast scintillators enabling lower costs, higher reliability and easier system integration than current approaches
- **CMOS imagers**:
  - Fast, low-noise and affordable wafer-scale devices.
- **3-D integration**
  - Direct wafer-to-wafer bonding (has been developed for consumer imaging applications (e.g. in mobile phones)
- **Scaling:**
  - Continuous increase in computing power/area for the ROIC.
- **Assembly:**
  - New assembly technologies to enable smaller/lighter overall device sizes (e.g. 3D printing).





OmniVision OV23850 PureCel-S General Structure



Long Term Goal

Make a new generation of X-ray spectral imaging devices based on photon counting using indirect detection in combination with a large-area CMOS imager wafer-bonded to an advanced ROIC.

In order to achieve the goal of **increasing performance** and **higher reliability** at **lower cost**, we need to focus on:

- **Increase detector Size:**
  - Applications call for several cm^2.
  - Yield values 80 to 90% minimum for 8 to 12 inch wafers.
  - Need for alternative IC architectures.
- **Reduce Cost:**
  - Trade-off between Size and Yield.
  - Need for large area detector Assembly Technologies.
  - Research for (new) Hybrid Device Architectures.
  - Wafer Processing, Packaging and Assembly reduction needed.
  - 3D printing potentially beneficial.
- **Improved Scintillators:**
  - Scintillators with a high light output, high resolution, small decay times and high stopping power.

Potential Impact

Medical:

- Patient examinations: quicker, sharper images and lower doses.
- Medical diagnostics: bone densitometry and mammography, tissue or material identification

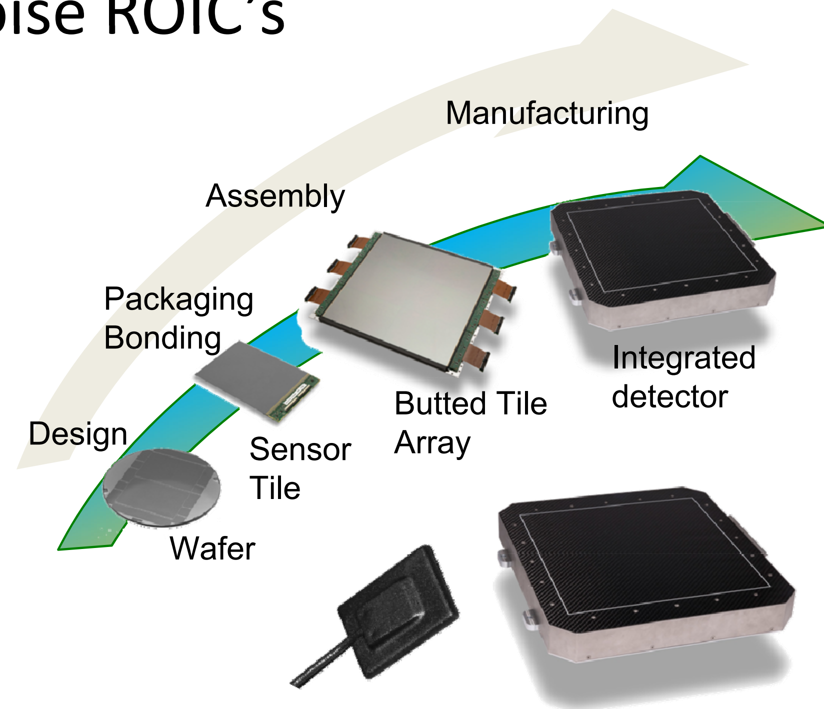
Security:

- Identify dangerous or forbidden substances hidden in closed containers, suitcases and bags.

Competences and Contributions

Teledyne Dalsa Professional Competences and possible contributions

- Application Knowledge
- Leader in wafer-scale CMOS imagers
- Expertise in high-speed low-noise ROIC's
- In-house advanced assembly process development
- X-ray conversion: modelling, optimization and evaluation



Looking forward to ATTRACT partners for research projects!

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