Hexagonal Silicon Drift Detectors By Mirion Technologies

Mathieu Morelle[1], Jytte Elseviers[1], Sofie Put[1], Menyhert Kocsis[2], Simon Benichou[2] and Cédric Cohen[2]

[1] Mirion Technologies (Canberra Olen) NV, Lammerdries-Oost 25, 2250 Olen, Belgium, mmorelle@mirion.com

[2] European Synchrotron Radiation Facility, Grenoble, France

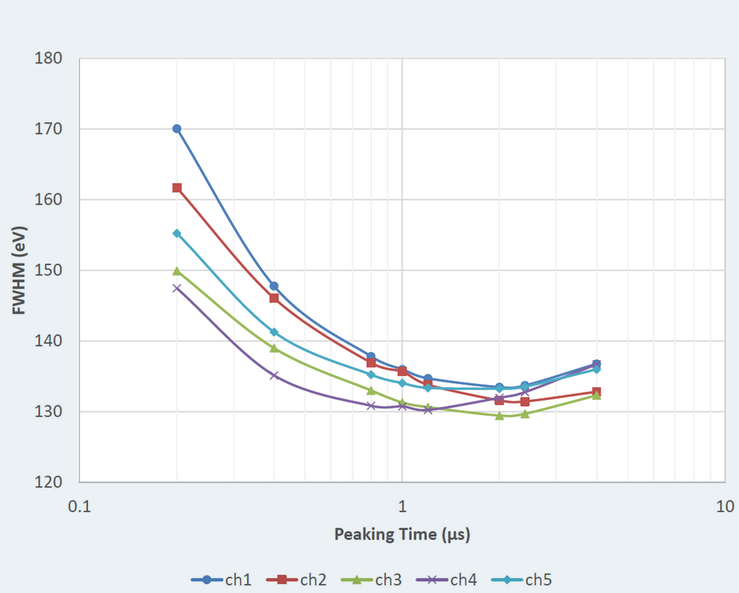
Correspondence to: jelseviers@mirion.com

Introduction

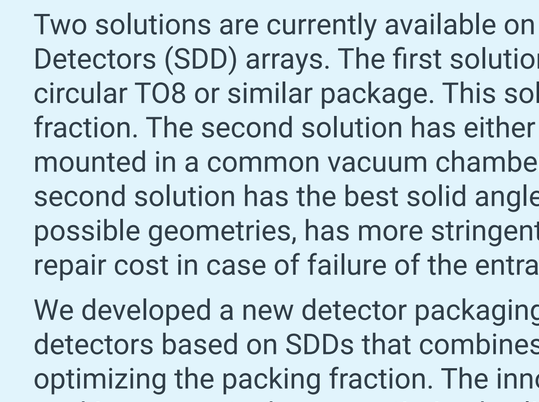
Two solutions are currently available on the market for multi-element Silicon Drift Detectors (SDD) arrays. The first solution is based on individual SDDs mounted in a circular TO8 or similar package. This solution is very inefficient in terms of packing fraction. The second solution has either individual elements or monolithic arrays mounted in a common vacuum chamber with a common entrance window. This second solution has the best solid angle coverage but provides less flexibility in possible geometries, has more stringent constrains for maintenance and has a high repair cost in case of failure of the entrance window.

We developed a new detector packaging for arrays of solid-state X-ray fluorescence detectors based on SDDs that combines the advantage of individual mounted SDDs optimizing the packing fraction. The innovative vacuum compatible hexagonal packing geometry has an optimized solid angle coverage and a reduced dead area between the individual elements. The individual modules have separate entrance windows and thermo-electric coolers. The hexagonal packaging provides a large flexibility and modularity in configuration, a simplified maintenance by easy replacement of an individual module in case of failure of the entrance window or detector while maintaining a minimal packing fraction.

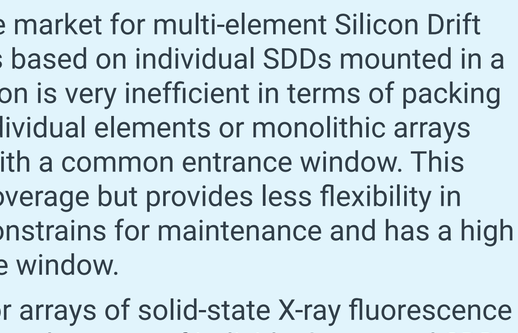
First Results 5-Element Array



Traditional Approaches

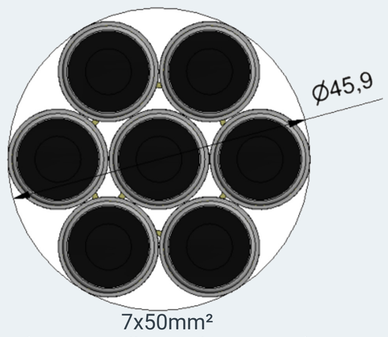


- Discrete or monolithic arrays
- Excellent packing fraction
- Less flexibility in configuration
- Risk of one common window

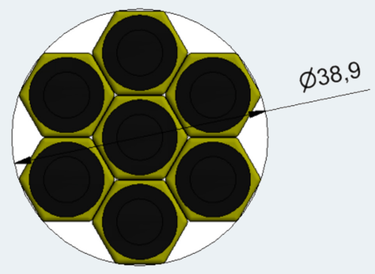


- Individual elements
- Poor packing fraction
- High flexibility

Excellent Packing Fraction

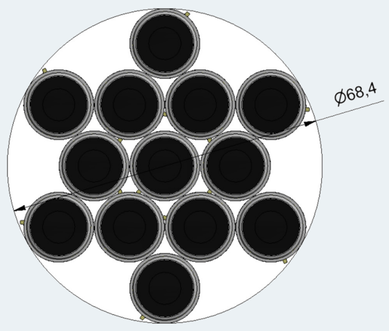


7x50mm²
(70mm² collimated to 50mm²)

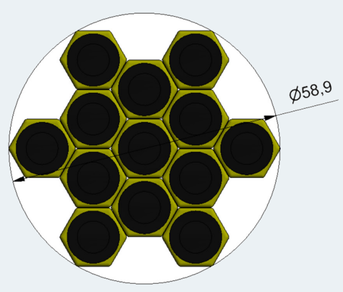


7x55mm²
(75mm² collimated to ~55mm²)

Gain of 7 mm in diameter



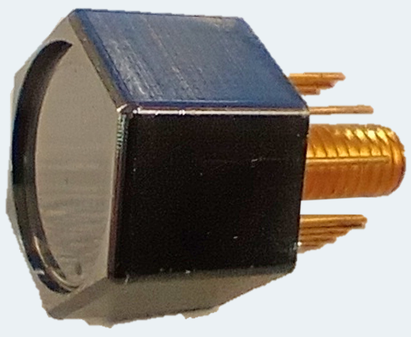
13x50mm²
(70mm² collimated to 50mm²)



13x55mm²
(75mm² collimated to ~55mm²)

Gain of 10 mm in diameter

New Detector Packaging



Hexagonal silicon detector and hexagonal package:

- Individually mounted SDDs
- Optimized packing fraction & solid angle coverage
- Reduced dead area between the elements
- Separate entrance window
- Thermo-electric coolers
- Large flexibility and modularity in configuration
- Simplified maintenance

Specifications:

- Vacuum encapsulated design
- No weld lip (higher packing fraction)
- Hermetic seal on bottom of header (compatible with vacuum chambers)
- SDD active area
- 75mm² uncollimated
- ~55mm² collimated
- Cooling performance: ΔT of >100K

Conclusion

Mirion Technologies developed a new type of silicon drift detector, a hexagonal drift detector in a hexagonal package. In a multi-element configuration this brings the advantages of discrete/monolithic arrays (with one common window) and individual packaged elements together:

- Excellent packing fraction (and thus increased solid angle)
  - The nose diameter can be reduced by 15% to 20% compared to circular packages
- High flexibility in the design
  - Multi-element arrays with hexagonal packages can be tailored to the needs of the customer
  - 1 up to at least 19 elements are possible in different configurations
- No risk of one common window
  - If the window of one of the hexagonal elements breaks, measurements can be carried on with the remaining elements

These advantages come at (almost) no cost in performance of the silicon drift detector elements:

- Count rates up to several Mcps are possible
- Energy resolution of <135eV at optimum shaping time
- Energy resolution of typically <175eV at 1 Mcps input count rate
- Energy resolution of typically <165eV at 0.2µs peaking time
- Peak-to-background > 10 000:1

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