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Ge-on-Si photodetector array for sensitive infrared imaging

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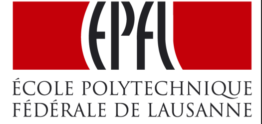
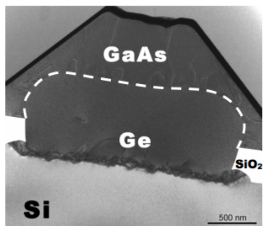


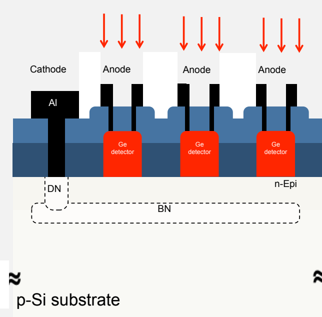
- **Main goal**
  - Create a Germanium PD array
  - Near-infrared detection range
- **Why Ge-on-Si**
  - Ge bandgap of 0.67eV
  - Suitable for near-infrared applications
- **What has been done**
  - Single Ge-on-Si diodes fabricated and tested
  - 300x1 Ge line arrays fabricated and tested

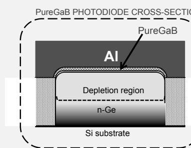
300x1 Ge-on-Si Photodiode Array Process Flow

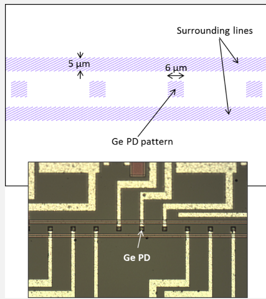


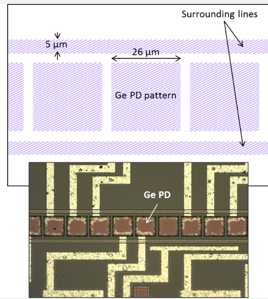
Cross-sectional TEM images of selective Ge epitaxy grown on patterned Si followed by in-situ growth of a GaAs layer

- Cross-sectional TEM image of selective Ge growth
- Schematic of the PureGaB Ge-on-Si photodetector arrays
- Ge deposition for low defect density Ge-on-Si island growth
- Ga deposition for ultrashallow $p^{+}n$ junction
- B deposition for good ohmic contacting of the p^{+} Ge-island anode to an Al metal interconnect





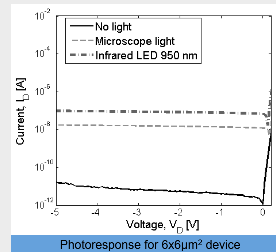




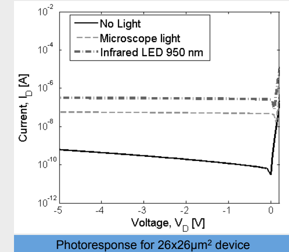
- Top-view cell of the Ge-PD design (top) and the microscopic-view of the fabricated arrays (bottom) with two sizes of a) 6×6 µm² and b) 26×26 µm²

Ge-on-Si SPAD and Line Array Experimental Results

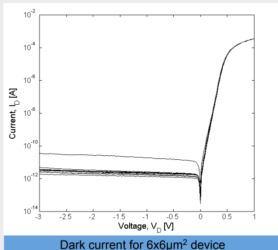
- **Specifications of Ge Line Array**
  - 300×1 arrays of PureGaB Ge-PDs with 2 PD sizes of 6×6 µm² and 26×26 µm²
  - Uniformity of the fabricated devices over the array in terms of I-V characteristics and photoresponses
  - A new process module for metal removal on the Ge-islands,



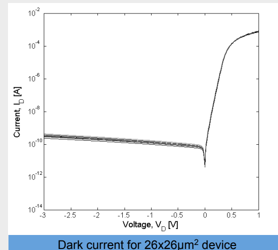
Photoresponse for 6x6µm² device



Photoresponse for 26x26µm² device



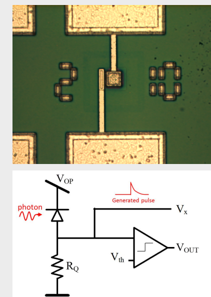
Dark current for 6x6µm² device



Dark current for 26x26µm² device

Performance (APD/linear mode)	Min.	Typ.	Max.	Unit
Active area	4		40	µm²
Breakdown voltage for 2×2 µm²	9			V
Breakdown voltage for 2×20 µm²			13	V
Breakdown voltage		11		V
Dark current @ 1V reverse bias	2		20	pA
Performance (Geiger mode)				
Excess bias voltage	0		4	V
DCR @ Ve = 1V	10		60	kHz
I_d/I_{ref} @ V_e=3V			25	%
FWHM Time jitter			900	ps

Performance summary



- **Specifications of Ge APDs**
  - Can be operated both in proportional and in Geiger mode
  - Low dark counts and reasonably high sensitivity at room temperature
  - Low values of reverse current, series resistance and ideality factor

Conclusion & Future Plans

- The fabricated detector array is operational in linear mode with high yield
- The device shows very good sensitivity to near infrared light with good I-V performance that is, to our knowledge, best in the literature

Future work

- Improving the device to operate in SPAD mode
- Integrating the pre-amplification circuit in the same chip together with the device