



Surface-normal electroabsorption modulator arrays for optical interconnects

Bertrand Noharet
Acreo

Acree – R&D in electronics, optics and communication technology



Departments

Industrial Nano- & Microtechnology

Photonics

IR-Detectors (QWIP)

Packaging / Organic Informatics

System Level Integration

150 employees, 23 MSEK turnover

2600m² clean room

3900m² lab

ISO 9001 Certified

Surface-normal electroabsorption modulator

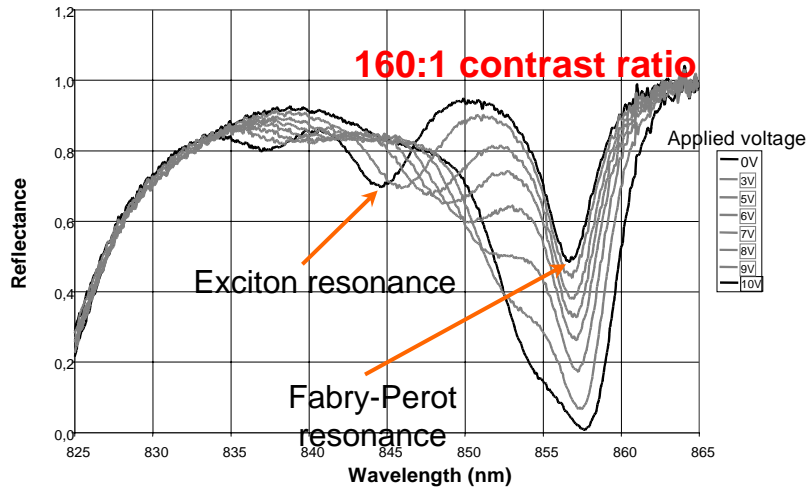
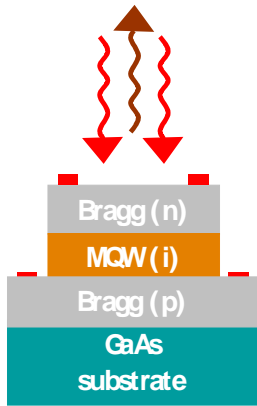
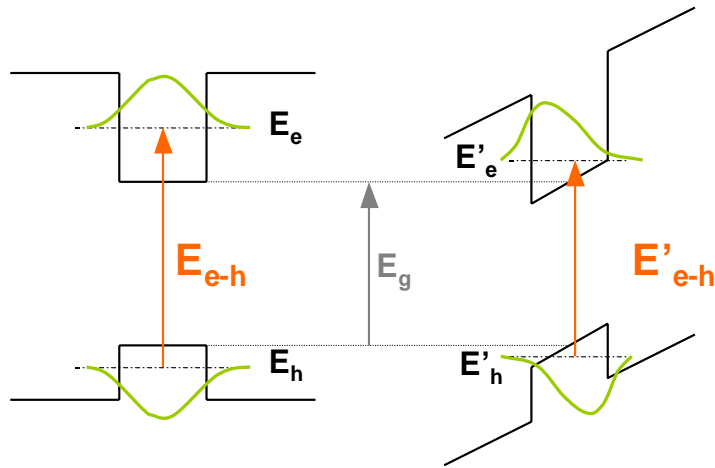


Quantum confined Stark effect

- electroabsorption: shift of the resonant absorption peak

Enhanced modulation effect with Fabry-Perot resonator

- higher contrast ratio
- access to phase modulation



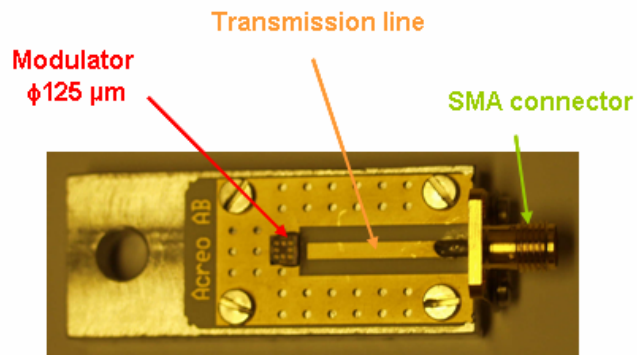
Main properties



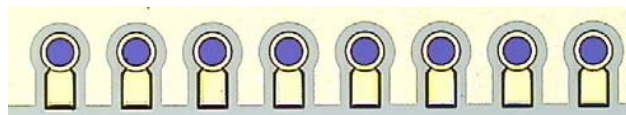
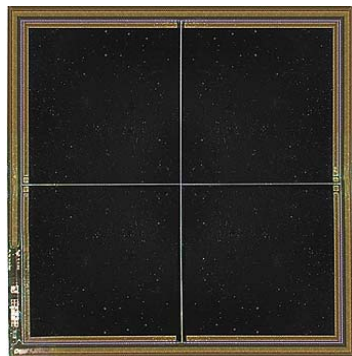
- Wide apertures (free-space optics - waveguide)
- High modulation speed (10kb/s - 10Gb/s)
- Integration in large 1-D & 2-D arrays
- Low-cost manufacturing (VCSEL)
- Insensitive to light polarisation

⇒ **parallel processing & communication channels**

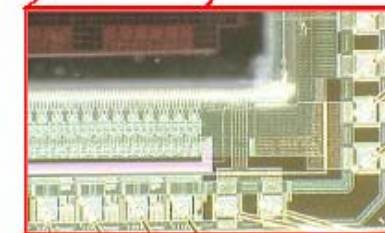
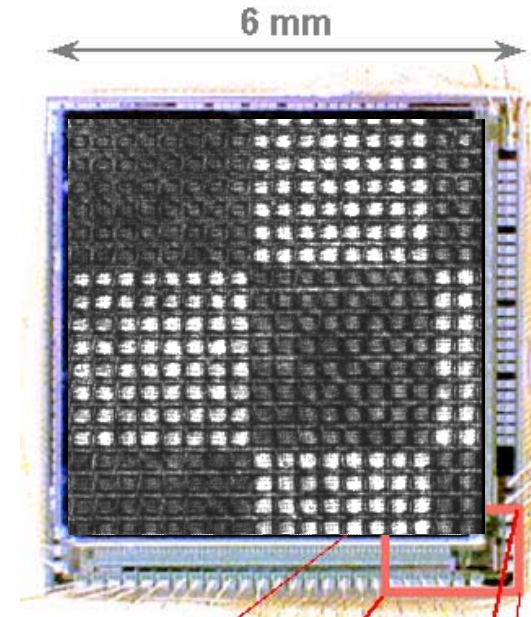
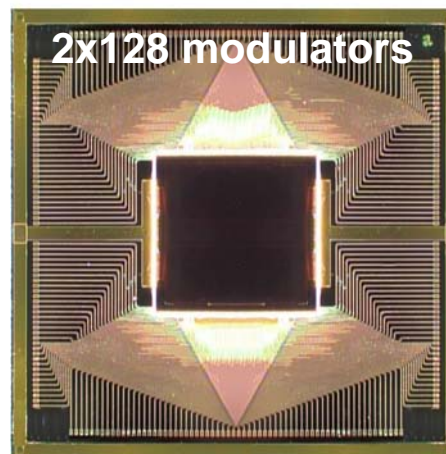
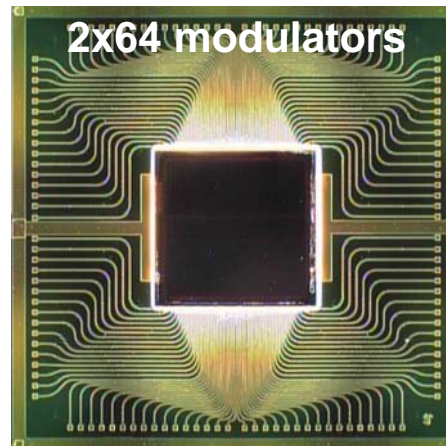
Examples of components (850-1550nm)



14.6 mm



250-300 μm



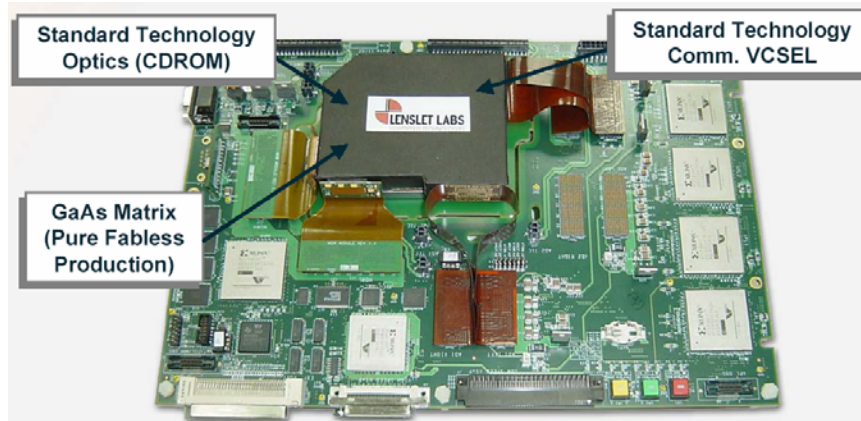
128x128 modulators

Applications



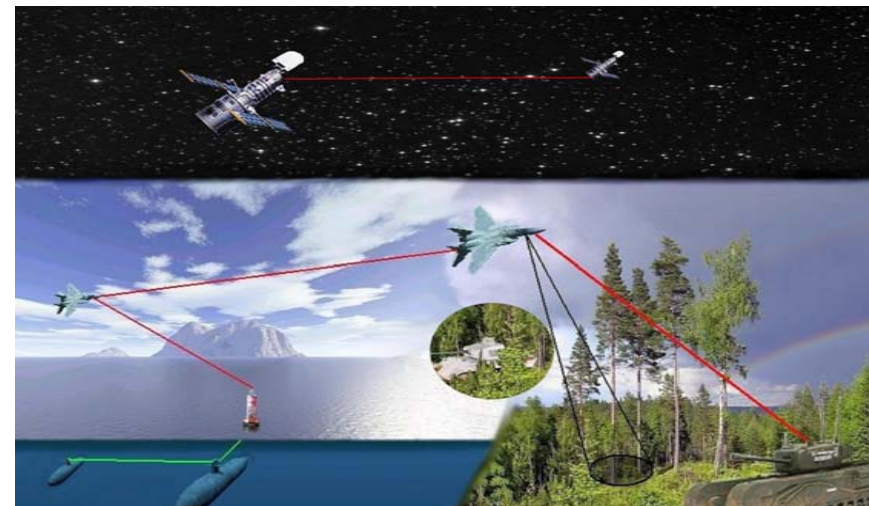
Signal processing

- optical pattern recognition
- vector-matrix multiplier
- microwave signal processing
- optical header recognition



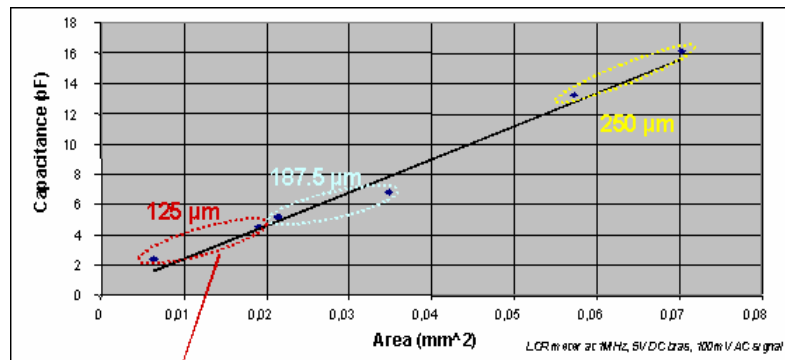
Wireless optical communication

- corner-cube retroreflector
- cat's eye optical design
- duplex mobile communication

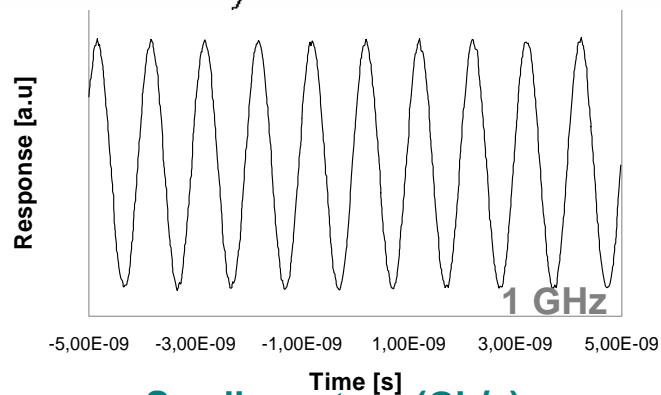


Performance and trade-offs

Modulation speed (RC limited)

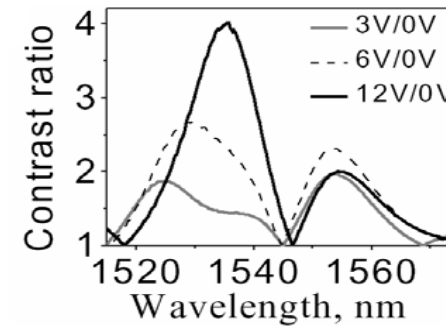


$$\left. \begin{array}{l} C \approx 3 \text{ pF} \\ R \approx 50 \Omega \end{array} \right\} \Rightarrow f_{3dB} \approx 1.1 \text{ GHz}$$

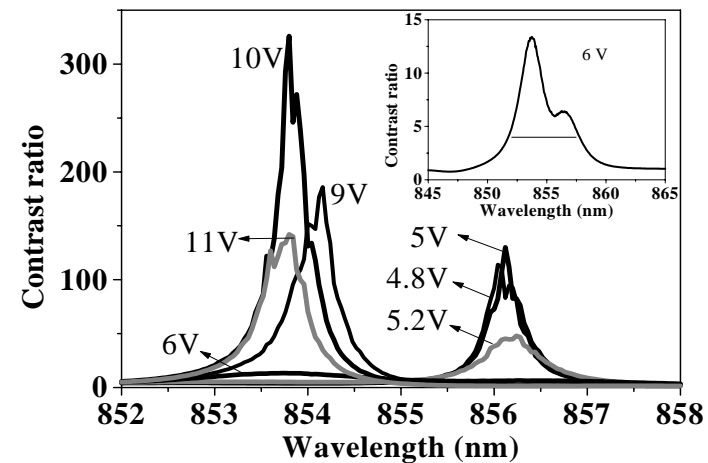


Small aperture (Gb/s)

Contrast ratio & optical bandwidth



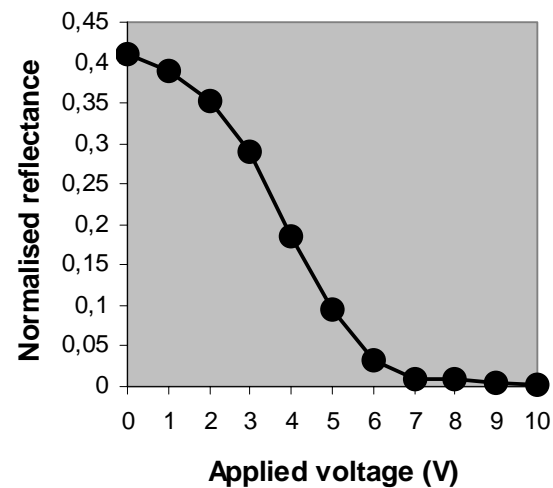
Non-resonant design – CR<10:1



Resonant design - CR>100:1

Performance and trade-offs

- Analogue amplitude response
(binary phase modulation possible)



- Dual-mode operation: modulator / detector

Conclusion

- Compatible with free-space and waveguide technology
- Large 2-D array flip-chip bonded to drive electronics
- High speed, low power consumption
- Duplex operation (modulator/detector)
- Mature technology

⇒ Surface-normal modulators for optical interconnects?

- *Optoelectronic packaging (hybridisation, passive alignment, Si microbenches, semi-hermetic packaging, ...)*

