

Ge-based VCSEL technology

2022 EPIC Online Technology Meeting on VCSELs
Technology and Applications

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Our Group structure



CATALYSIS

Automotive Catalysts
Precious Metals Chemistry
Fuel Cell & Stationary Catalysts



ENERGY & SURFACE TECHNOLOGIES

Rechargeable Battery Materials
Cobalt & Specialty Materials
Metal Deposition Solutions
Electro-Optic Materials

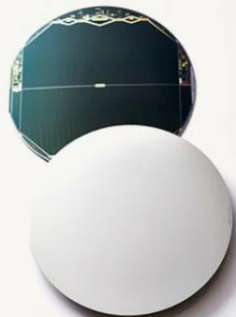


RECYCLING

Precious Metals Refining
Precious Metals Management
Jewelry & Industrial Metals
Battery Recycling Solutions

Electro-Optic Materials

Germanium
Products



Germanium
Services



Infrared
Optics

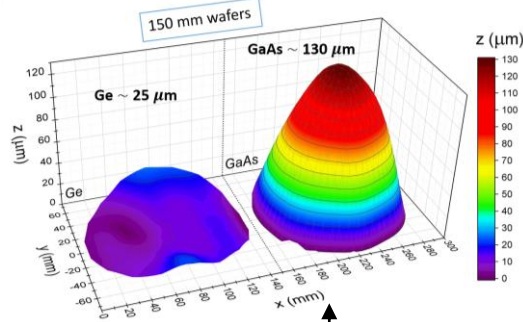


Optical
Coatings



VCSEL technology and applications

Institute for Compound Semiconductors (ICS) & CS Manufacturing Hub (Cardiff University)



iPhone X
Face ID module
6"



Automotive LiDAR Has Arrived

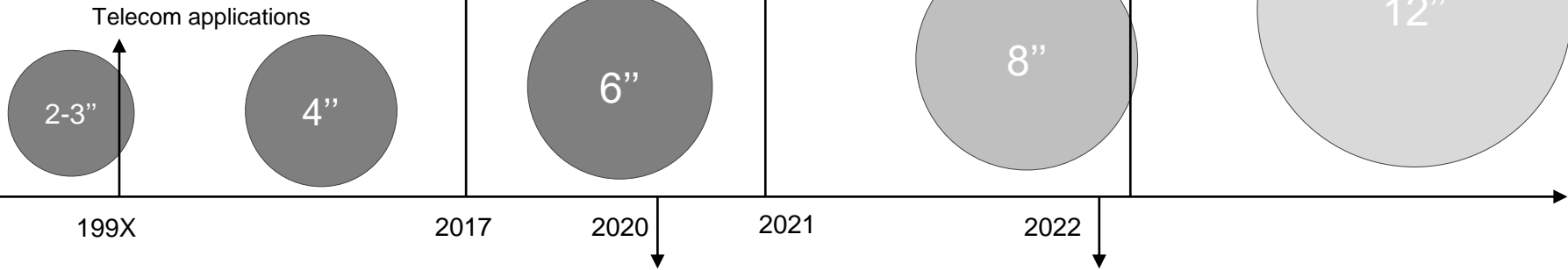
Sabir Rangwala Senior Contributor @ I write about perception, sensors and LiDAR for autonomous vehicles, drones and robots Follow

May 24, 2022, 10:17pm GMT

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By May 2022, Daimler Mercedes is the first manufacturer in Germany to start testing a system for highly automated driving that can completely take control in gridlocked traffic on the autobahn. Photo: Capstan RealLife (Photo by Capstan: Instagram alliance via Getty Images) [-]



Telecom applications

2-3"

4"

6"

8"

12"

199X

2017

2020

2021

2022

iPhone 12 Pro
LiDAR introduction



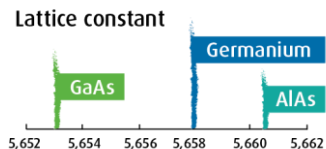
IQE announces the world's first commercially available 200 mm (8") VCSEL wafer

<https://www.iqep.com/media/press-releases/2022/iqe-announces-the-world-s-first-commercially-available-200-mm-8-vcsel-wafer/>

Germanium substrates

The natural choice for GaAs based photonics applications

Lattice match



Ge (Germanium)

Optimal Ge lattice constant



A perfect Ge lattice match leads to 10x less wafer bow

Wafer bow: Ge + epi
-25 μm



6" Ge wafer with VCSEL epi stack

GaAs (Gallium Arsenide)

GaAs lattice mismatch with AIAs

Wafer bow increases cost and wavelength variation across the wafer

Wafer bow: GaAs + epi
+228 μm



6" GaAs wafer with VCSEL epi stack

Dislocations



Zero dislocations

Ge wafers have truly dislocation-free surface.



Zero dislocations

6" Ge wafer with VCSEL epi stack

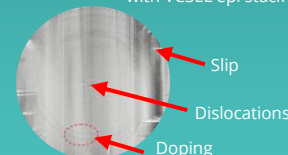


*vertical lines are XRT artefacts

GaAs cannot be dislocation free

6" GaAs wafer with VCSEL epi stack

Dislocations on GaAs wafer cause reliability issues.



Sustainability

The world needs new solutions to become more sustainable



- > Ge **recycling** is mature
- > Ge is **non-toxic**











- > As is **toxic**
- > As gets **landfilled**.



Germanium substrates

Germanium opens the road to new technologies

	Ge (Germanium)	GaAs (Gallium Arsenide)
Wafer cost	Significant Cost reduction potential 	Cost improvements have leveled off
Wafer size	Up till 12" available  	Limited offer on a market for 8" GaAs 
CMOS compatibility	Ge is compatible with CMOS foundries  Ge is used in transistor manufacturing and is well compatible with microelectronic fabs in terms of contamination and wafer size. As a result, it allows to explore VCSEL processing technologies using advanced CMOS fab equipment as well as integration schemes involving wafer to wafer bonding. 	GaAs cannot be used in CMOS environment Due to As contamination GaAs wafers cannot be introduced into CMOS fabs. As a result, devices processed on GaAs cannot be monolithically integrated with CMOS drivers at wafer level. In addition, it is not easy to selectively remove GaAs substrate, while Ge can be easily etched away selectively. 
Other factors	High electron and hole mobility 	GaAs is a standard industry solution 

Thank you for your attention!



Umicore, Electro-Optic Materials

Business Development Manager Photonics

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materials for a better life