

Emerging technologies for future THz car sensors and networks

Iwona Pasternak & Włodek Strupiński

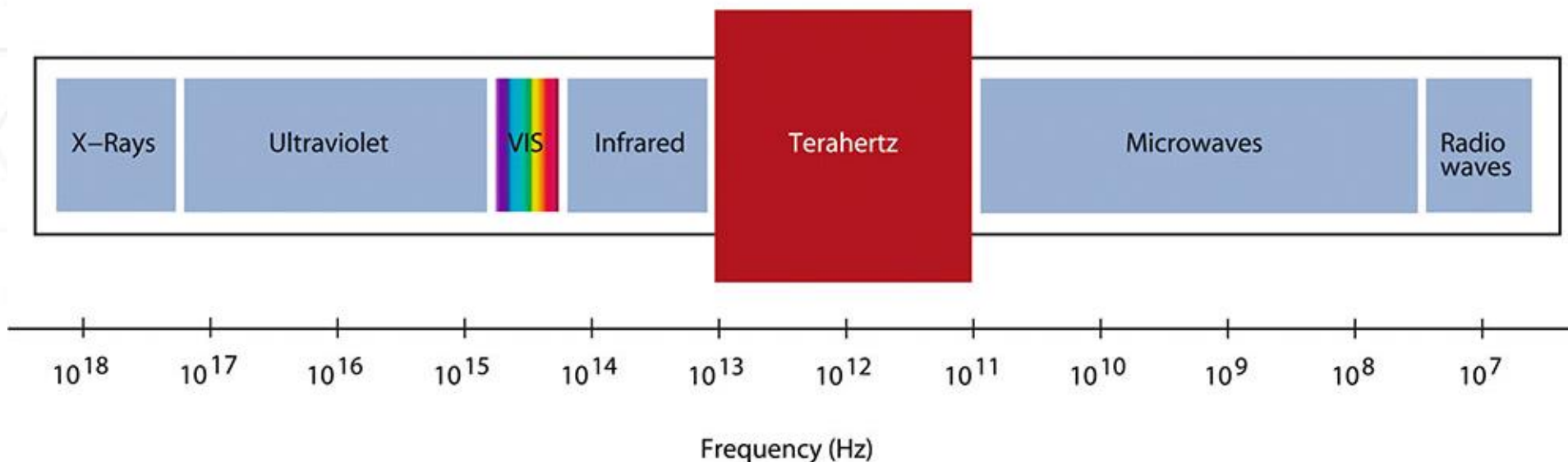
ENT, is a **semiconductor epitaxy company** that manufactures exceptionally high quality gallium arsenide (GaAs), indium phosphide (InP) related epitaxial structures for use in Quantum Cascade, VCSEL, Fabry-Perrot lasers, photodetectors, LEDs, transistors, photovoltaic cells and other devices for custom or short-run production to both commercial and R&D partners.



ENT, also produces **graphene** and other 2D materials for custom or short-run production to both commercial and R&D partners.

**CHALMERS****AIXTRON****Faculty
of Physics**

WARSAW UNIVERSITY OF TECHNOLOGY



Wavelengths of radiation in the THz band correspondingly range from 1 to 0.1 mm

- study important basic processes and physical properties of matter
- allow to investigate internal structures or content of objects
- THz waves **are harmless** to humans and animals
- Sub-THz waves **propagate through sand, fog or snow providing vision**
- wireless communication systems (industry, agriculture, for a non-destructive process monitoring or quality checks, **vision systems for difficult atmospheric conditions**, health...)

<https://www.toptica.com/technology/technical-tutorials/terahertz/terahertz-properties/>



Car2TERA

Terahertz sensors and networks for next generation smart automotive electronic systems

Partners



1

TECHNIKON

Technikon Forschung und
Planungsgesellschaft mbH
Austria [Villach]

2



KTH Royal Institute of
Technology
Sweden [Stockholm]

3



Infineon Technologies
Austria AG
Austria [Villach]

4



ENT SA
Poland [Warsaw]

5

veoneer

Veoneer Sweden AB
Sweden [Stockholm]

6



Anteral SL
Spain [Pamplona]

7



CHALMERS
Chalmers University of
Technology
Sweden [Gothenburg]

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ERICSSON
ERICSSON
Telecomunicazioni SPA
Italy [Pisa]

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ERICSSON
ERICSSON AB
Sweden [Gothenburg]





Car2TERA

The Car2TERA project will focus on two areas of research and development:

- in-cabin radar
- onboard data communications

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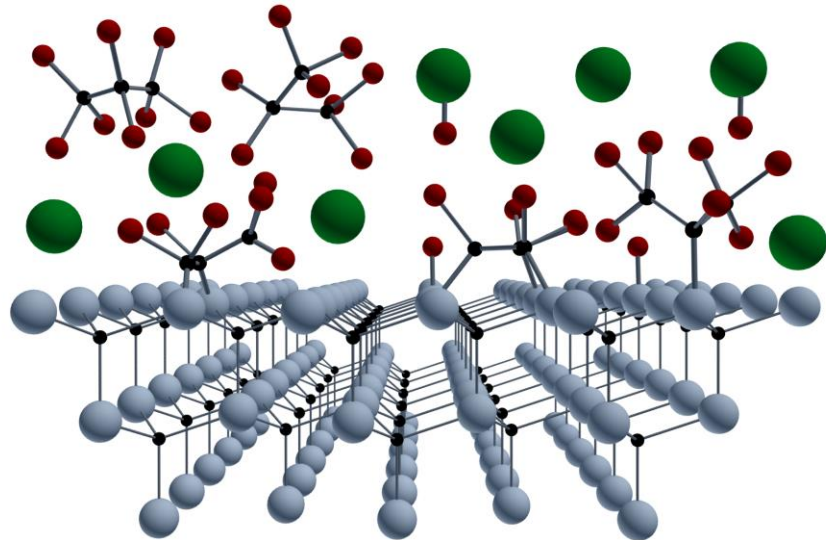


Graphene based **M**onolithic **M**icrowave **I**ntegrated **C**ircuit

- epitaxial graphene on SiC
 - high carriers mobility and concentration
 - high linearity and symmetry
-

Graphene based **M**onolithic **M**icrowave **I**ntegrated **C**ircuit

- **epitaxial graphene on SiC**

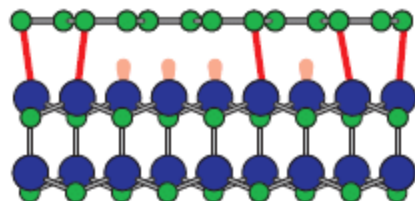


- resistant to popular cleaning procedures
 - unaffected by popular resists and developers
-

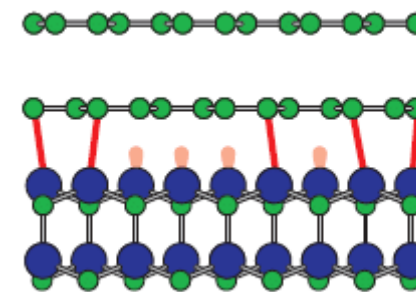
Graphene based **M**onolithic **M**icrowave **I**ntegrated **C**ircuit

- **high carriers mobility and concentration**

CVD of monolayer



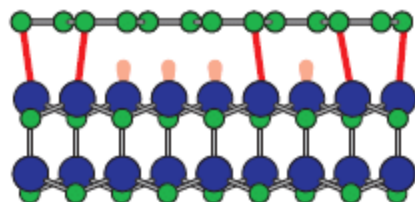
CVD of bilayer



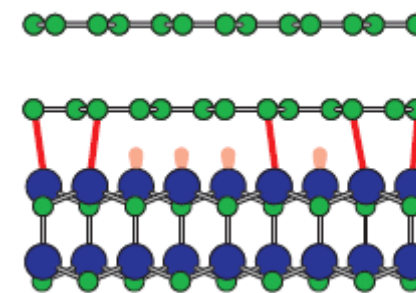
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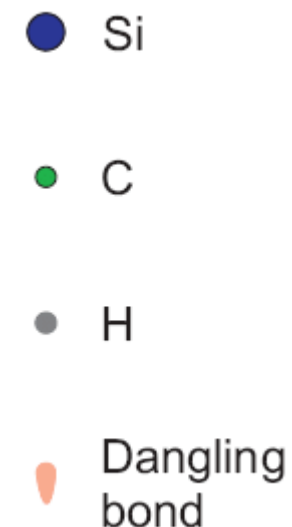
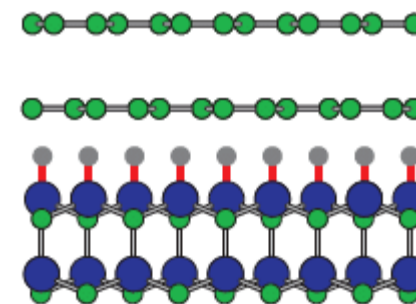
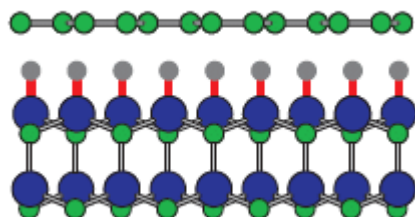
CVD of monolayer



CVD of bilayer

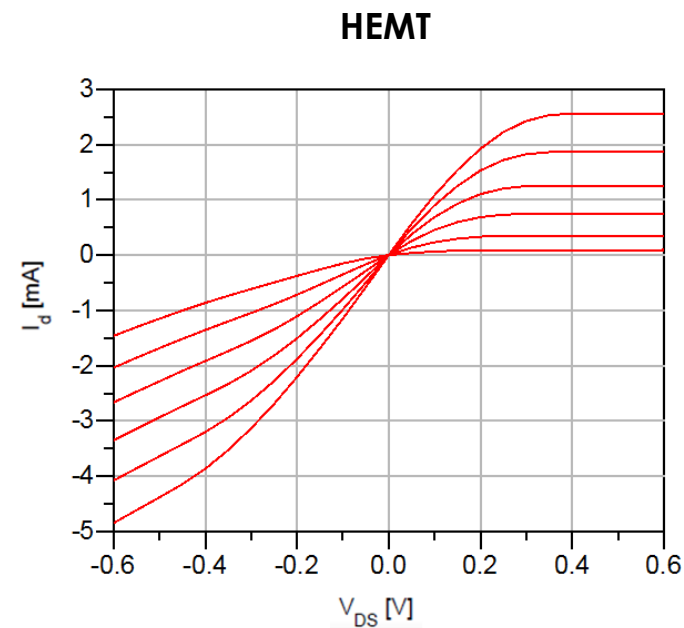
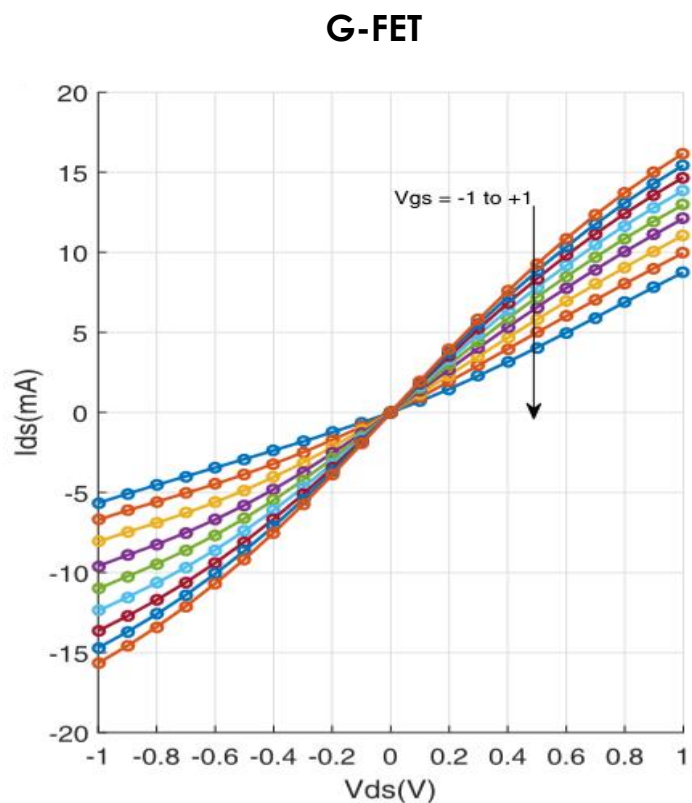


Hydrogen intercalation



Graphene based **M**onolithic **M**icrowave **I**ntegrated **C**ircuit

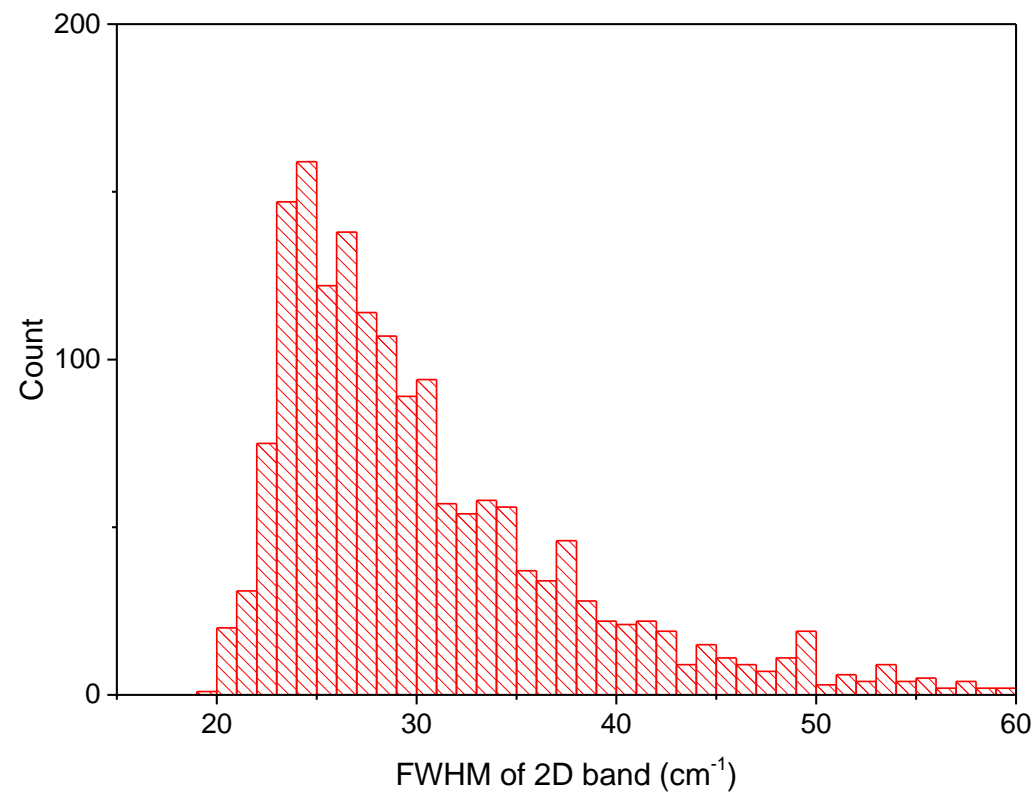
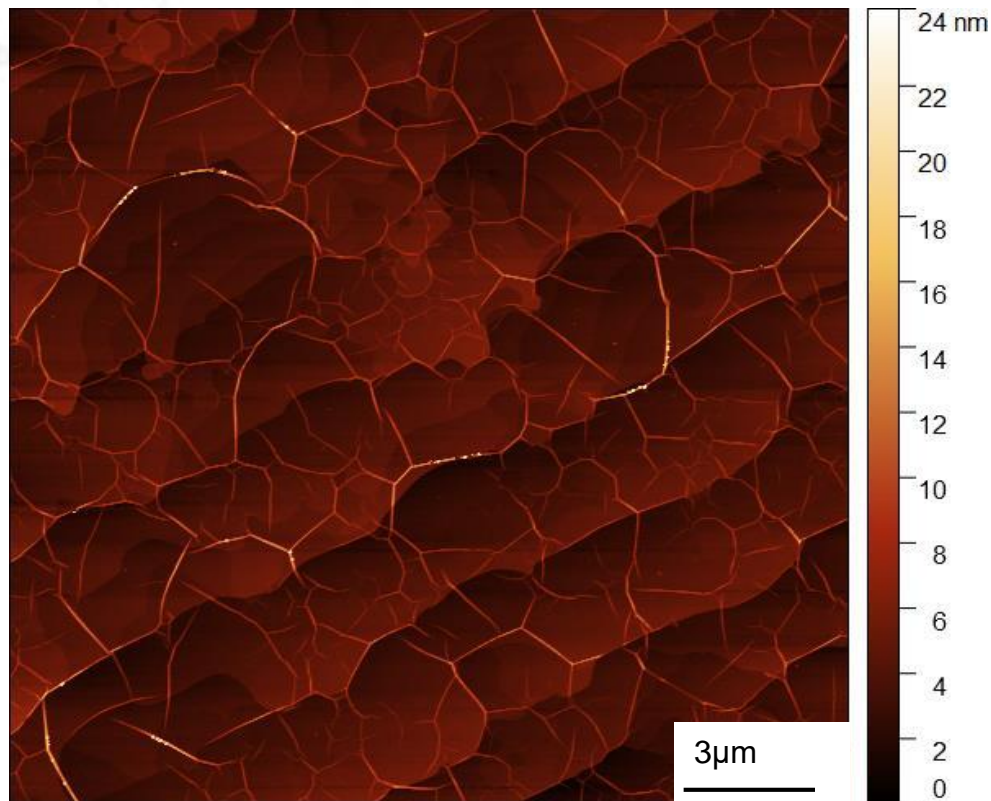
- **high linearity and symmetry**



eg: large-bandwidth mixer of frequency

Omid Habibpour, Zhongxia Simon He, Wlodek Strupinski, Niklas Rorsman & Herbert Zirath, Wafer scale millimeter-wave integrated circuits based on epitaxial graphene in high data rate communication, Scientific Reports 7, 41828 (2017)

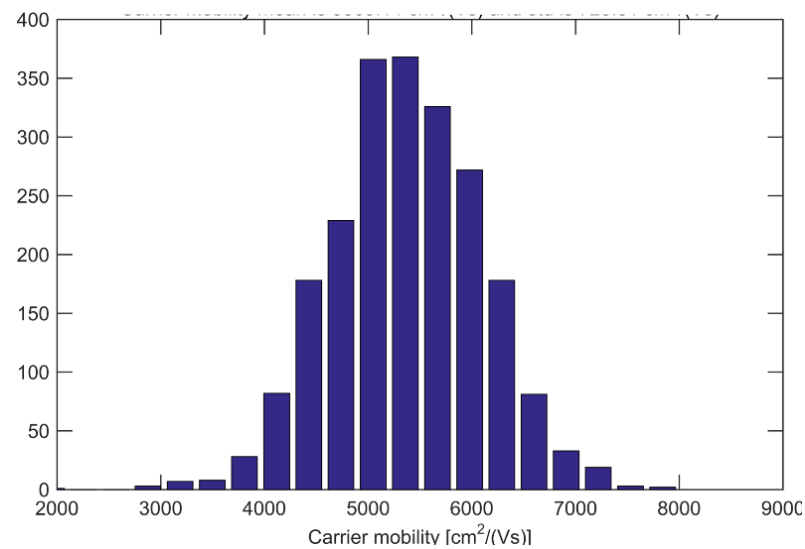
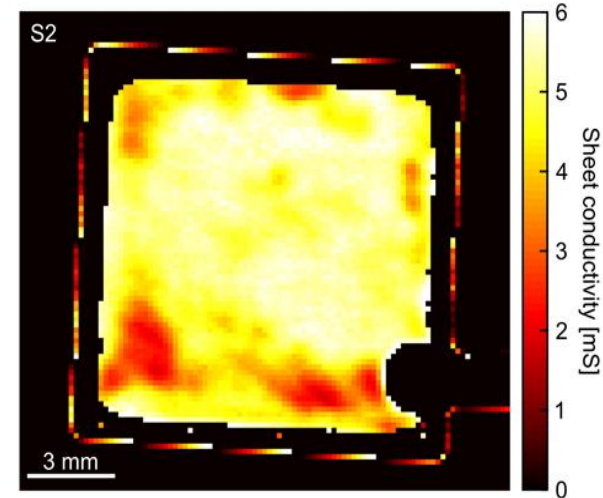
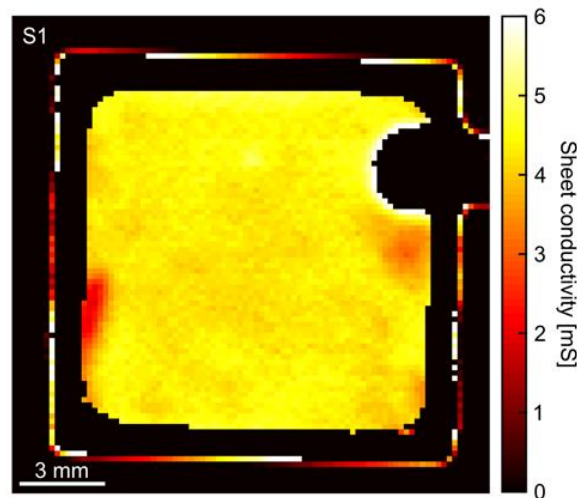
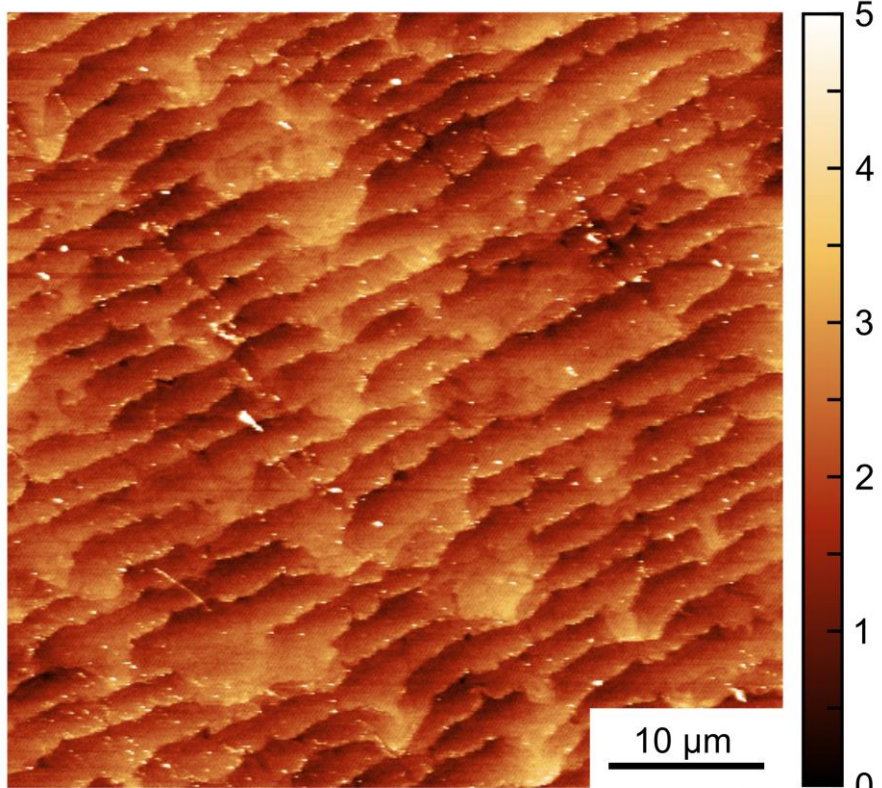
Monolayer Graphene on SiC



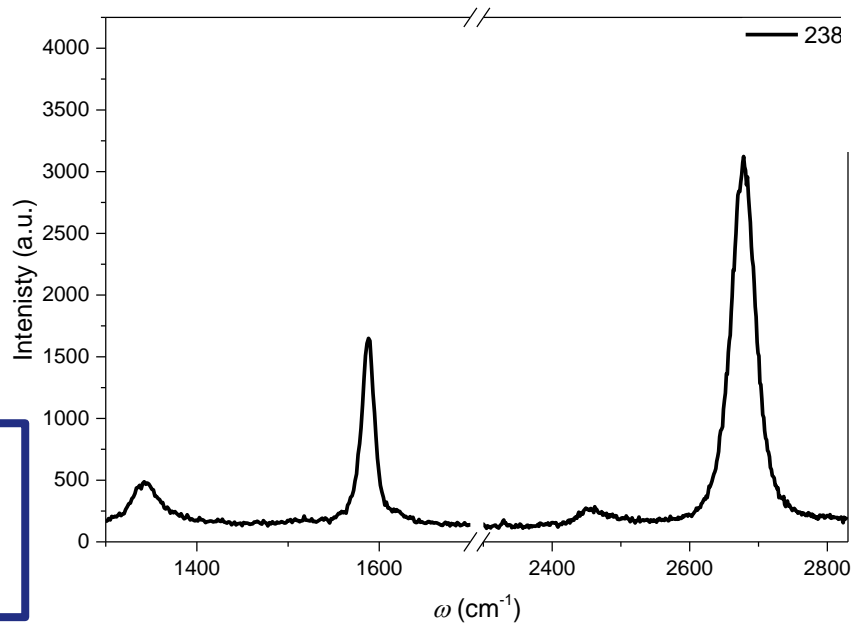
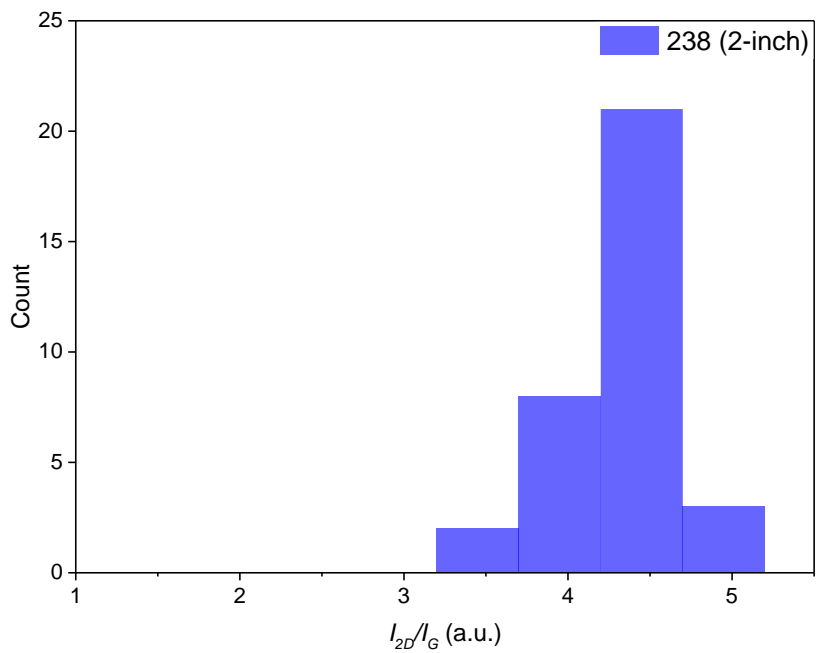
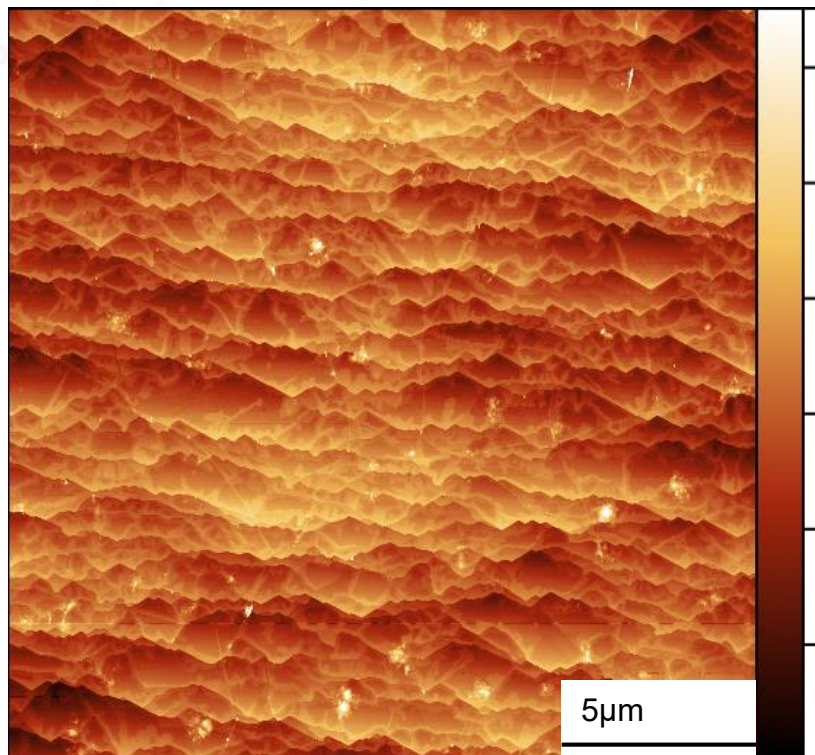
Qingbin Liu, Cui Yu, Zhihong Feng
National Key Laboratory of Application Specific Integrated Circuit,
Hebei Semiconductor Research Institute,
Shijiazhuang 050051, Hebei Province, China.

sample no1: $\mu = 8930\text{cm}^2/\text{Vs}$, $n = 6.15\text{E}+12\text{cm}^{-2}$, Rs 114
sample no2: $\mu = 6510\text{cm}^2/\text{Vs}$, $n = 7.08\text{E}+12\text{cm}^{-2}$, Rs 135

Bilayer Graphene on SiC



Graphene on Al₂O₃



In collaboration with:

AIXTRON



CCS 2D
19x2"
config

J. Sitek, WUT

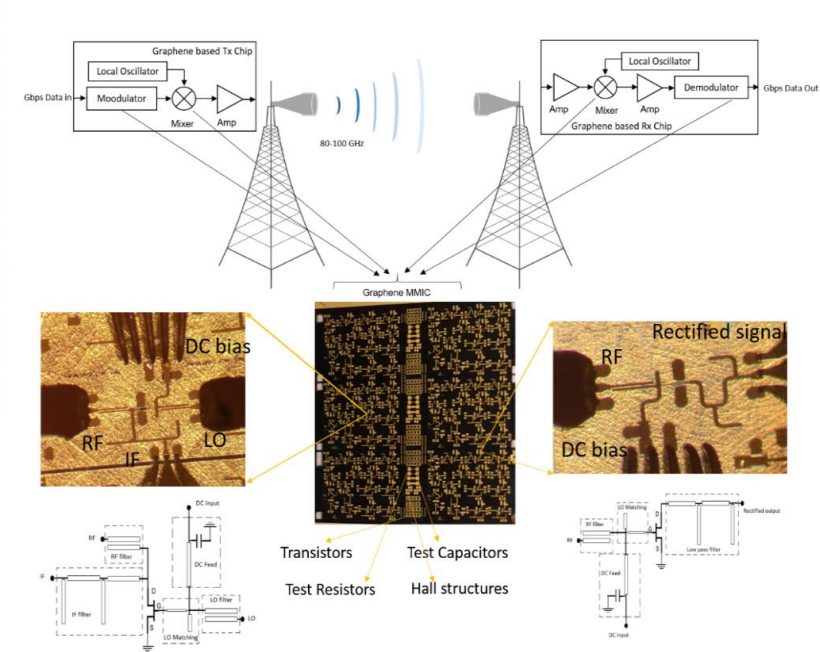
See also talk at 1215pm by:
Camilla Coletti
for more details



Wafer scale millimeter-wave integrated circuits based on epitaxial graphene in high data rate communication

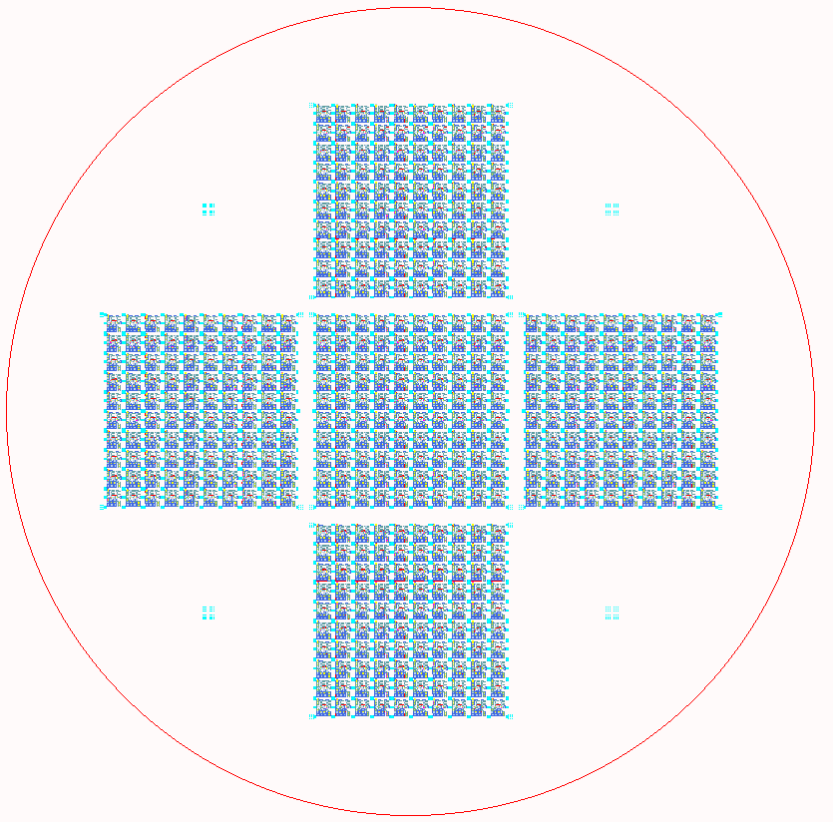


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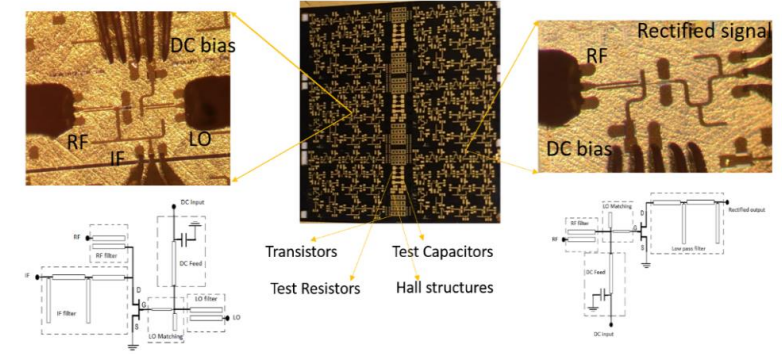
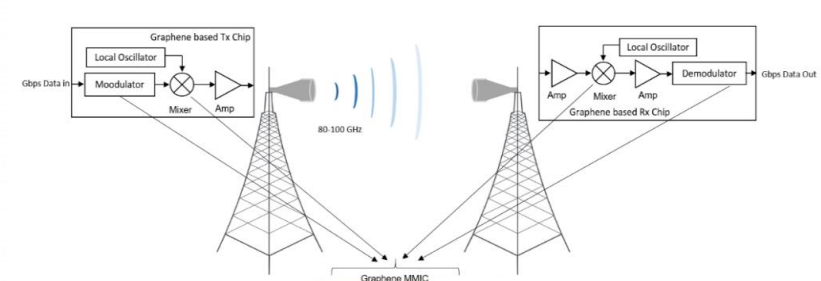


Omid Habibpour, Zhongxia Simon He, Wlodek Strupinski, Niklas Rorsman & Herbert Zirath, Wafer scale millimeter-wave integrated circuits based on epitaxial graphene in high data rate communication, Scientific Reports 7, 41828 (2017)

Wafer scale millimeter-wave integrated circuits based on epitaxial graphene in high data rate communication



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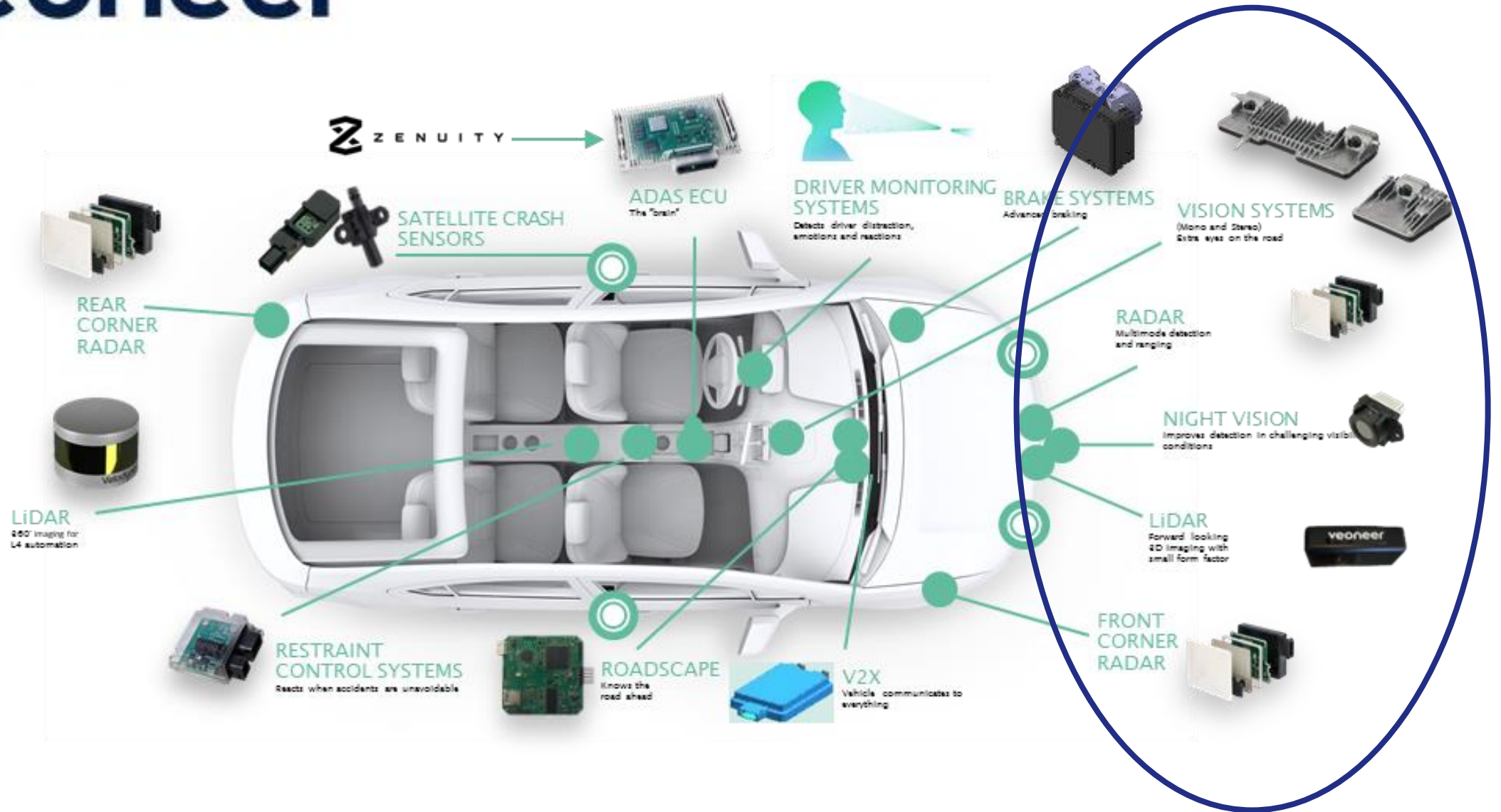


4-inch MMIC under fabrication

made on AIXTRON G5 WW



Omid Habibpour, Simon He and Herbert Zirath



thank you for your kind attention



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