2D PILOT LINE
FROM THE GRAPHENE FLAGSHIP

Leibniz Institute for high performance microelectronics

Graphene Photonic Devices in 200 mm Pilot Line

Ashraful Islam Raju, Mindaugas Lukosius

02.11.2026

IHP at Glance





Founded in
1983

Number of employees
400 +

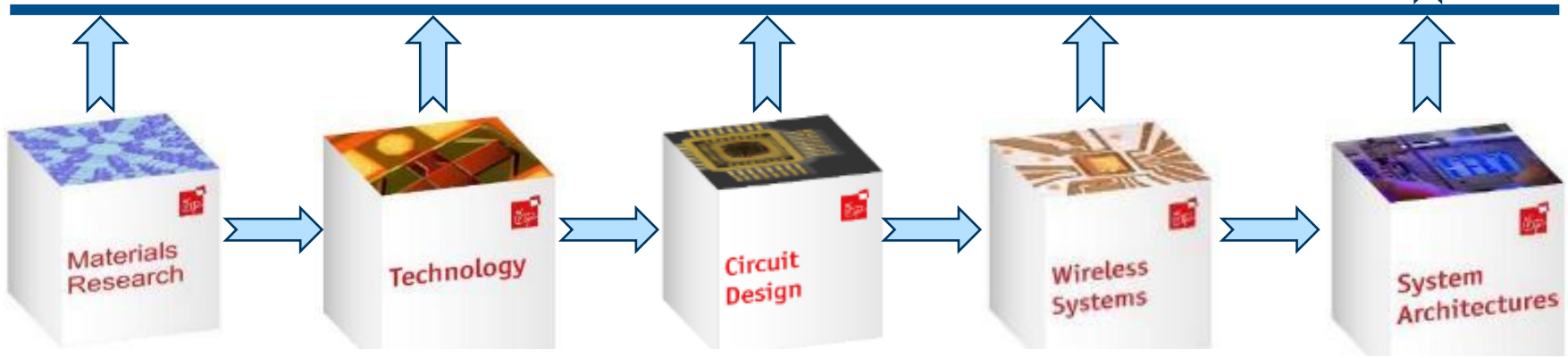
Nationalities
30 +

solutions

SERVICE

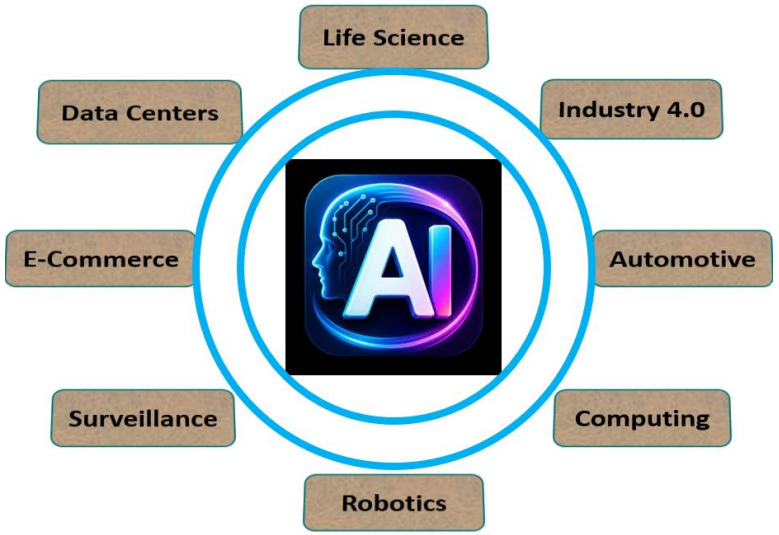
MPW

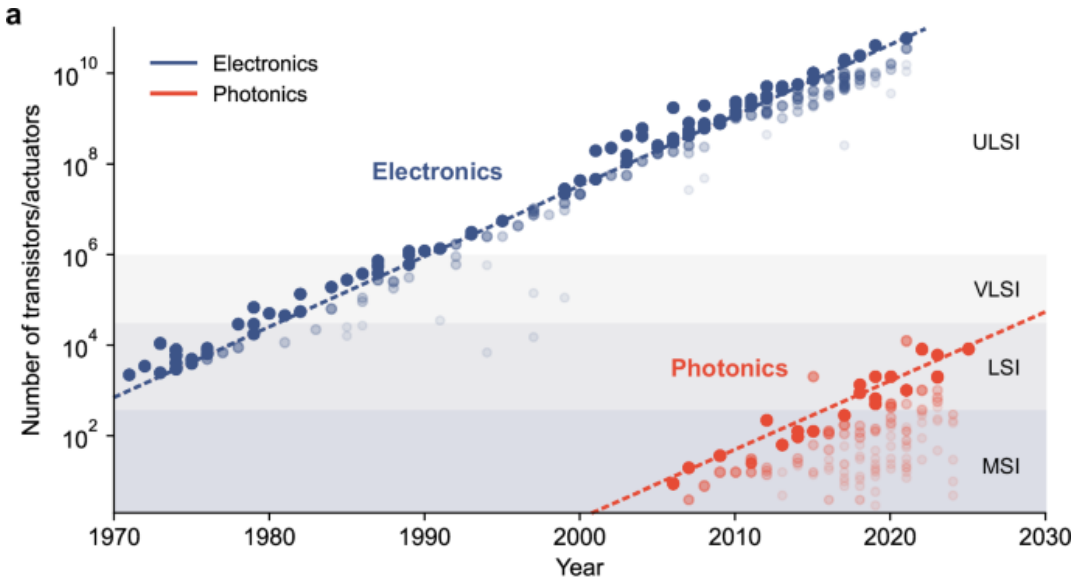
R&D

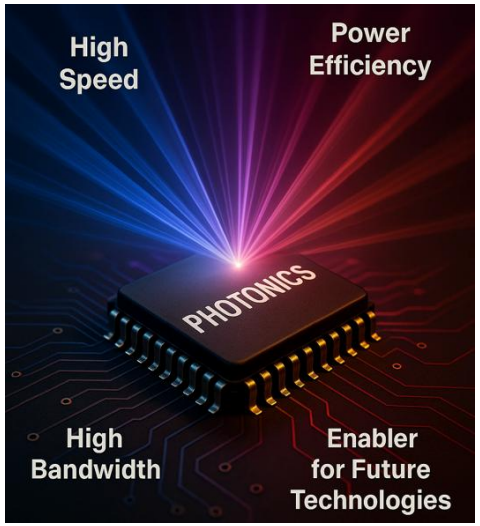


Unique selling point of a 200 mm pilot line for state-of-the-art BiCMOS technologies

Application of Photonics







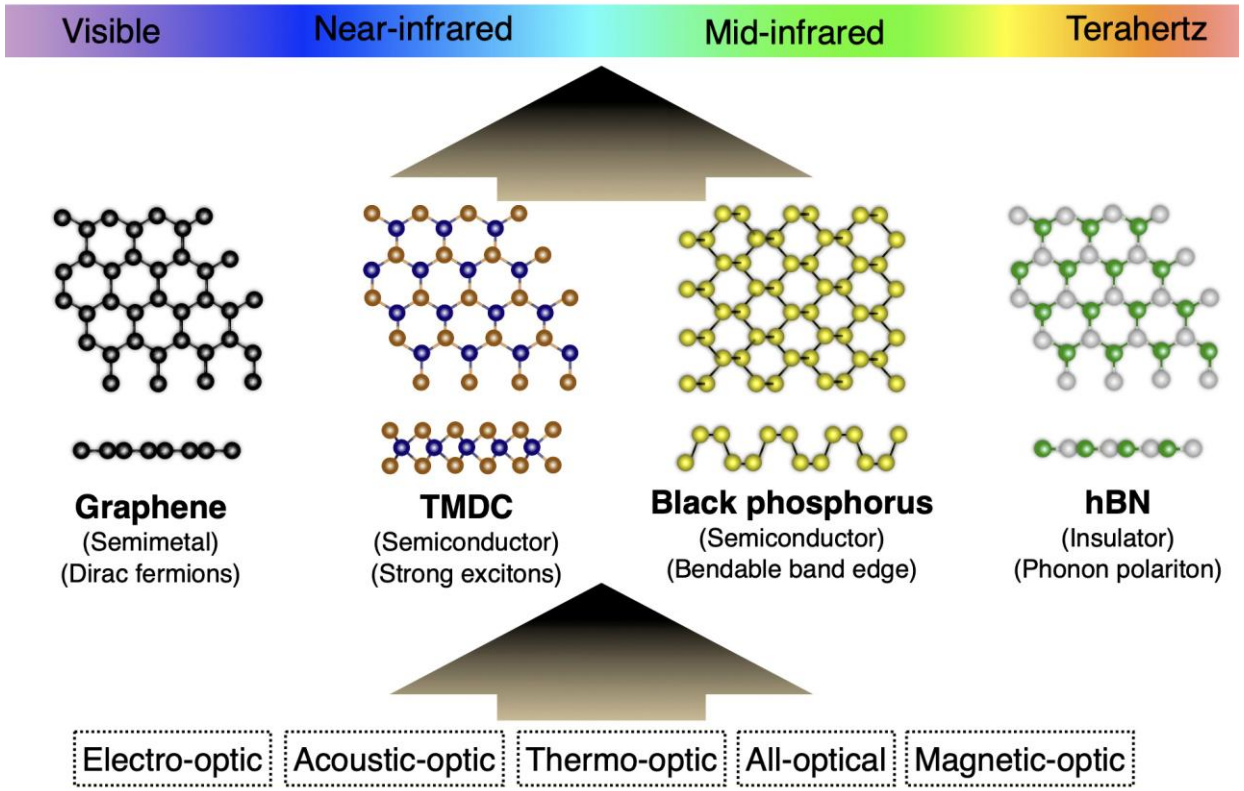
Large Amount of Data → **High-Speed and High-Efficient Systems** → **Optical and Photonics System**

Photonics Platform

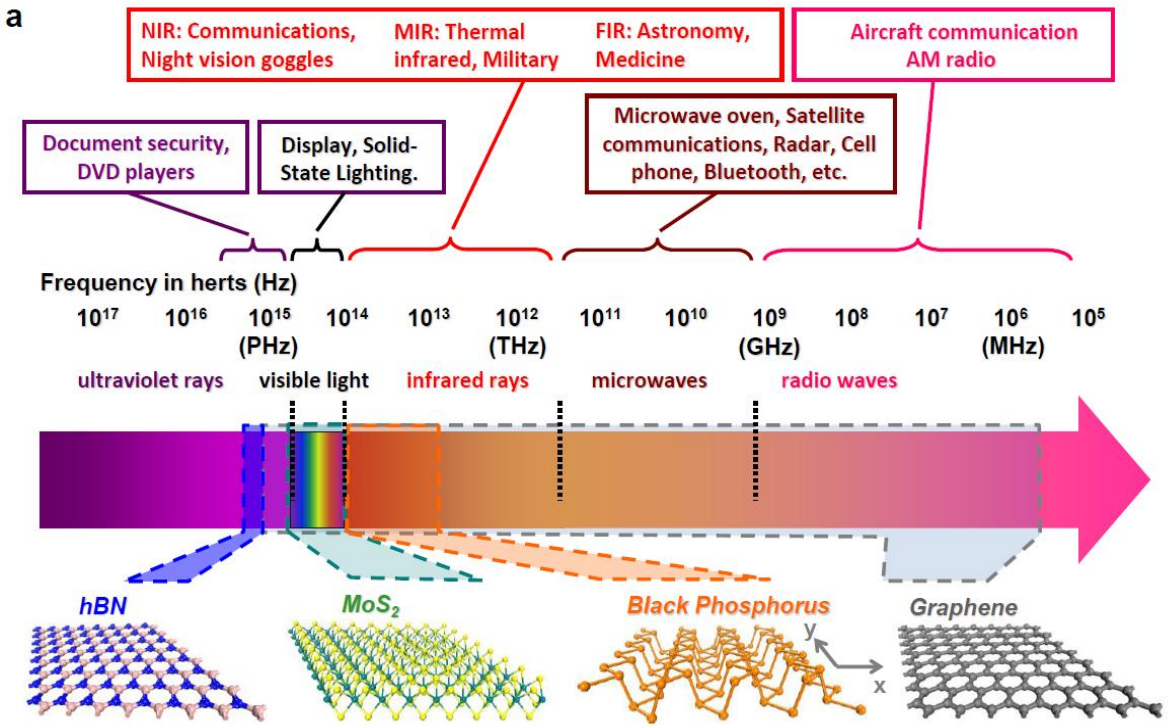
Silicon Photonics	High Speed/Efficiency, CMOS compatibilty, High Volume	Large device footprint, high loss operation
$LiNbO_3$	High Speed, low-loss operation	Large device footprint, No CMOS compatibilty
$BaTiO_3$ Plasmonic	High Speed, Compact footprint	Limited extinction ratio and efficiency
ITO	Compact footprint	Limited extinction ratio and efficiency, large dring voltage
Graphene	High Speed, High Extinction Ratio and Efficiency, CMOS compatibilty, Compact footprint	Low volume production

2D Material for Photonics

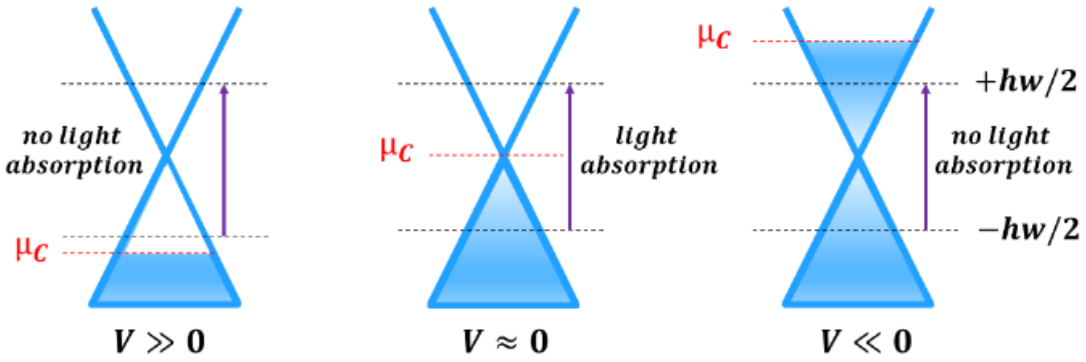
2D materials for modulations in wideband spectra

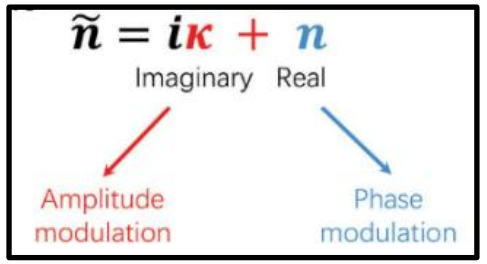


2D materials for photodetection in wideband spectra

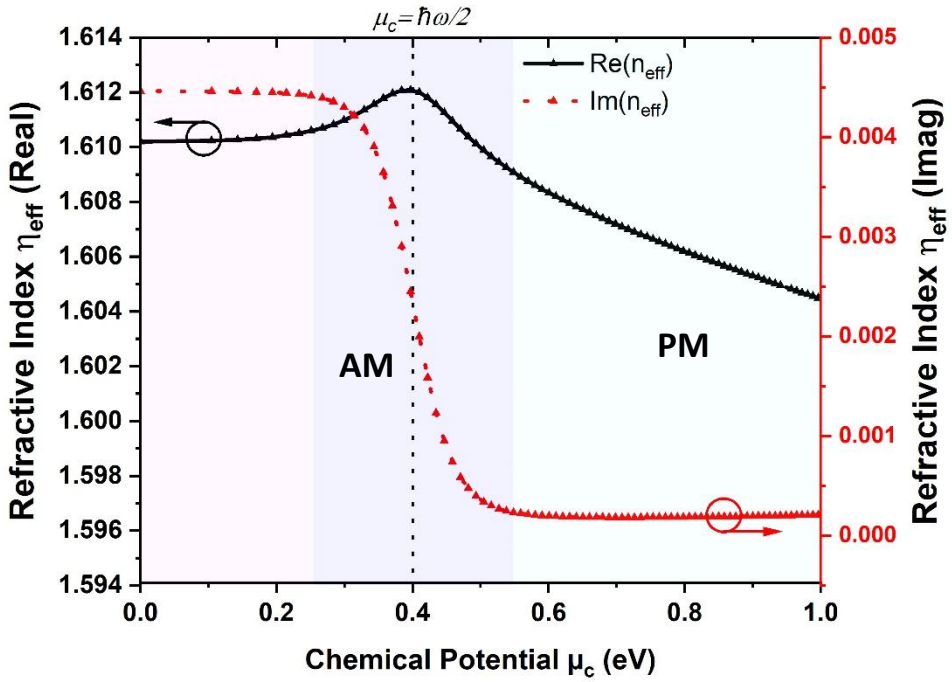


Graphene Photonics: Working Principle





- Broadband optical response (UV-THz)
- Strong interaction with the light (smaller footprint)
- Charge carrier density tuning by electrical gating
- Compatibility with CMOS technology – integration
- Lower power consumption



Silicon Vs Graphene Modulator

nature communications

Article

https://doi.org/10.1038/s41467-025-66566-2

Monolithic electro-optic platform on silicon with bandwidth of 100 GHz and beyond

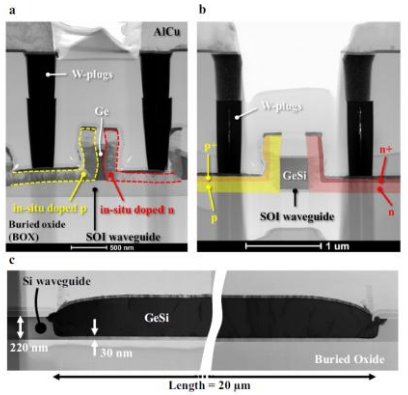
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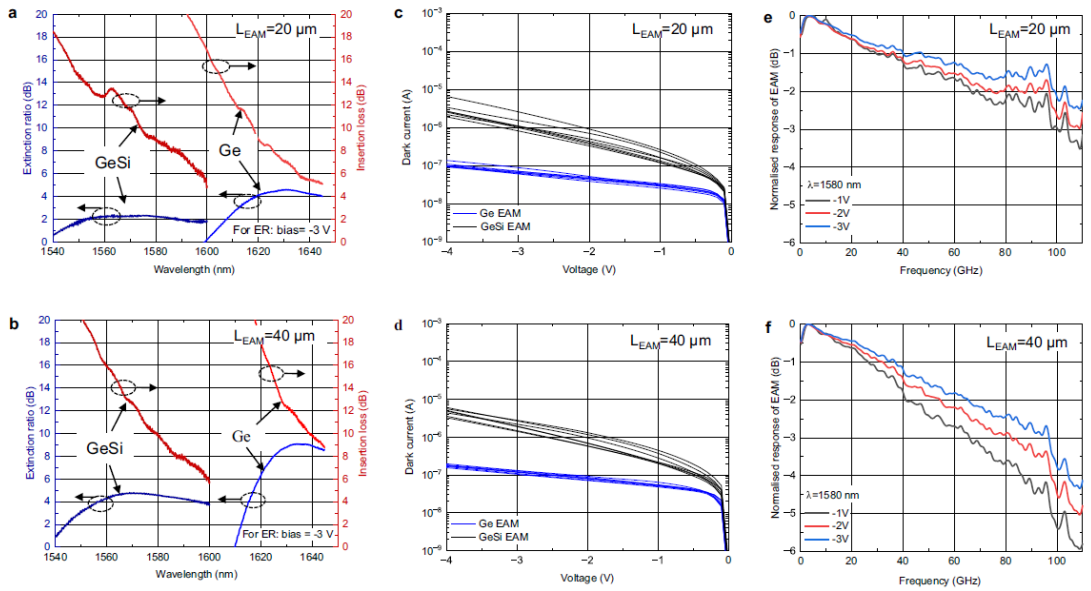
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Graphene Electro-Absorption Modulators for Energy-Efficient and High-Speed Optical Transceivers

M. Tiberi,[1] A. Montanaro,[2] C. Wen,[1] J. Zhang,[1] O. Balci,[1] S. M. Shinde,[1] S. Sharma,[1] A. Meersha,[1] H. Shekhar,[1] J. E. Muench,[1] B. R. Conran,[3] K. B. K. Teo,[3] M. Ebert,[4] X. Yan,[4] Y. Tran,[4] M. Banakar,[4] C. Littlejohns,[4] G. T. Reed,[4] M. Romagnoli,[2,5] A. Ruocco,[1] V. Sorianello,[2] and A. C. Ferrari[1,*]

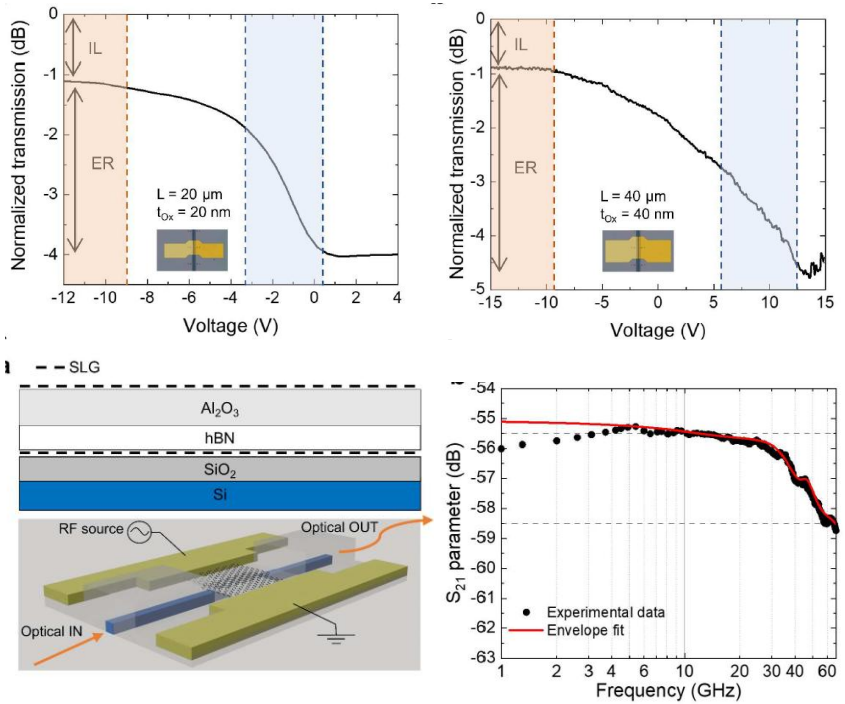
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[4]*Optoelectronics Research Centre, University of Southampton, SO17 1BJ, Southampton, UK*

[5]*CamGraPhIC srl, Pisa, Italy*



Germenium Vs Graphehe Photodetector

nature photonics

ARTICLES

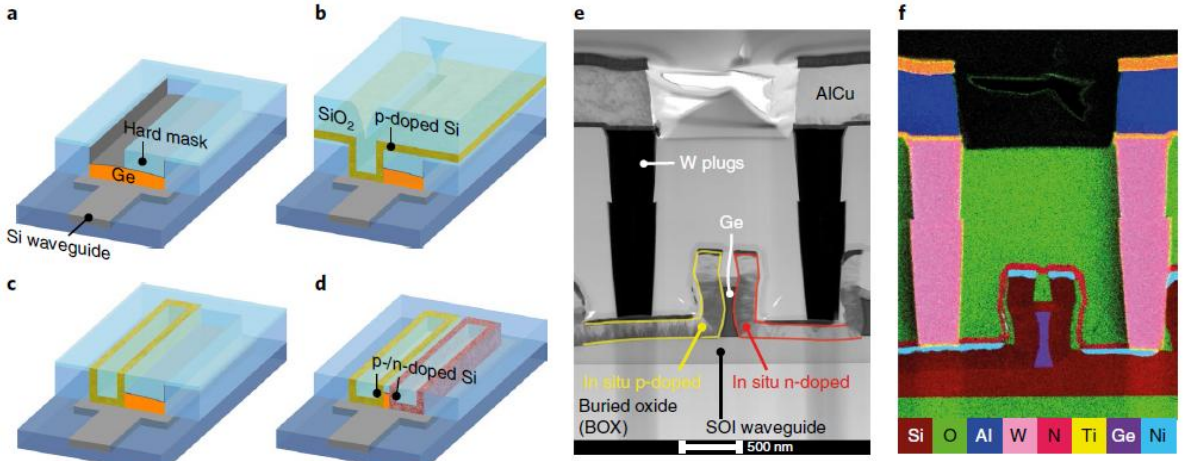
https://doi.org/10.1038/s41566-021-00893-w

Check for updates

OPEN

Ultra-fast germanium photodiode with 3-dB bandwidth of 265 GHz

S. Lischke[1]✉, A. Peczek[2], J. S. Morgan[3], K. Sun[3], D. Steckler[1], Y. Yamamoto[1], F. Korndörfer[1], C. Mai[1], S. Marschmeyer[1], M. Fraschke[1], A. Krüger[1], A. Beling[3] and L. Zimmermann[1,4]



ARTICLES

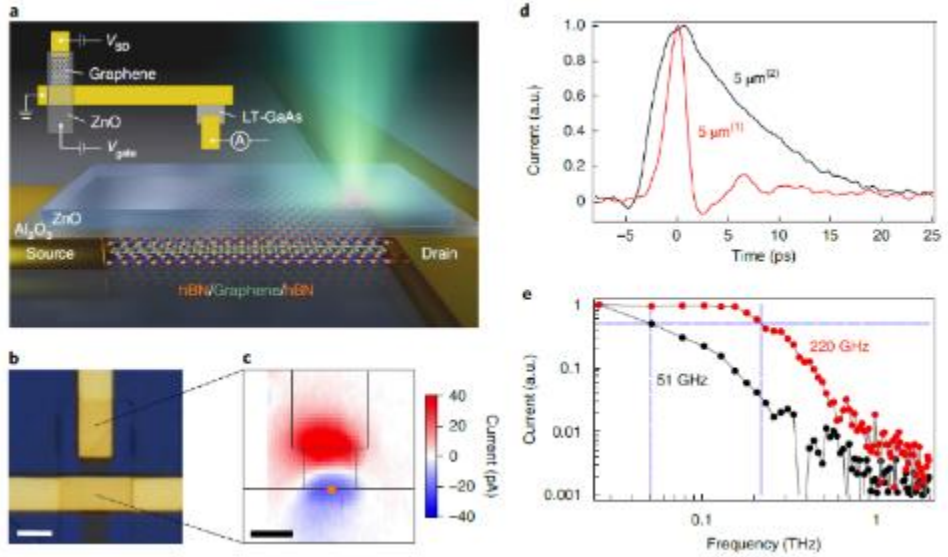
https://doi.org/10.1038/s41566-022-01058-z

nature photonics

Check for updates

Ultrafast intrinsic optical-to-electrical conversion dynamics in a graphene photodetector

Katsumasa Yoshioka[1]✉, Taro Wakamura[1], Masayuki Hashisaka[1], Kenji Watanabe[2], Takashi Taniguchi[3] and Norio Kumada[1]



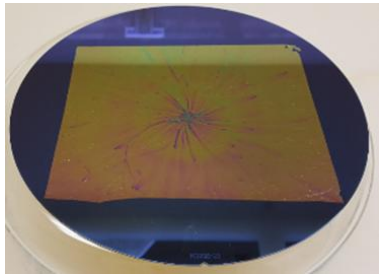
200 mm Pilot Line at IHP

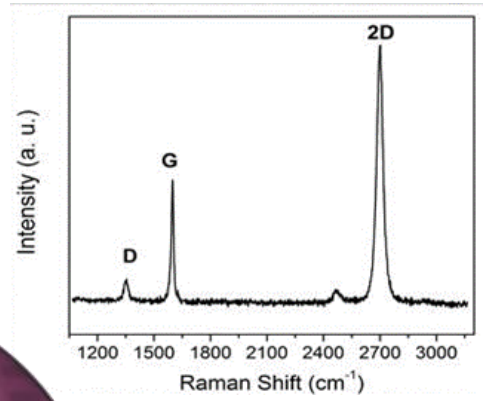
- **Cleanroom**
  - built in 1999 with approximately 1500 m^2
  - Cleanroom class 1 in wafer operation areas
- **Equipment**
  - equipment base for 250nm and 130nm BiCMOS
- **Performance parameter**
  - cycle time of 3 days/mask level
  - < 2 days/mask level for high priority
- **Delivery**
  - **50% capacity for R&D projects** and **50% capacity for MPW & Prototyping**
- **Work schedule and personnel**
  - seven days per week

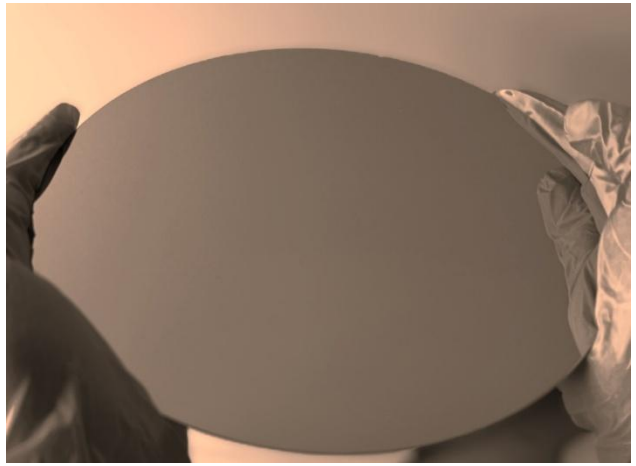


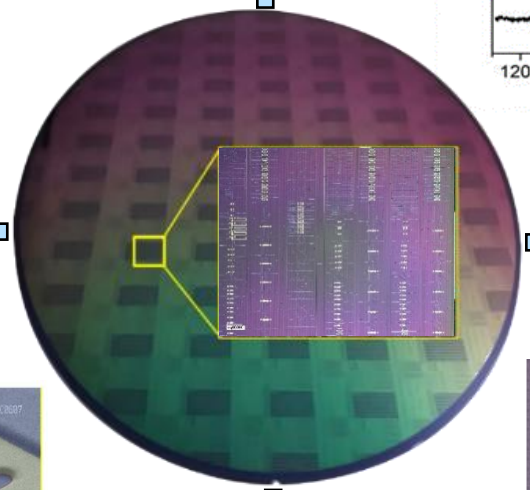


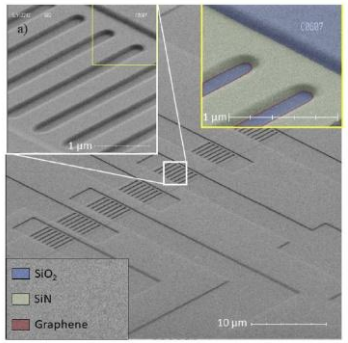
Graphene Research at IHP

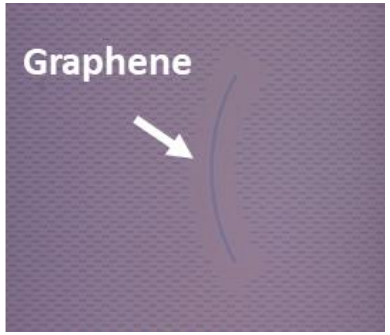


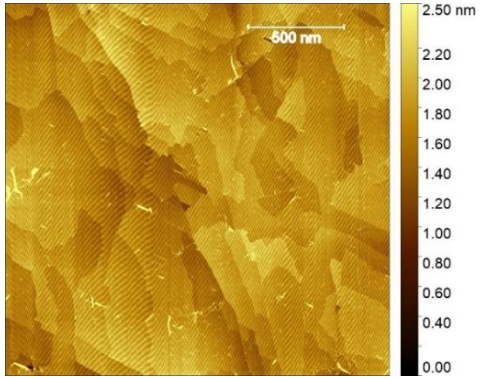


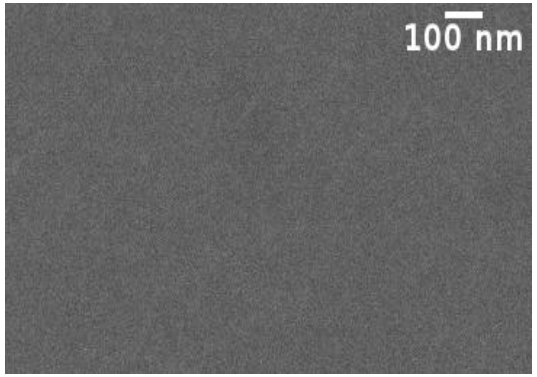




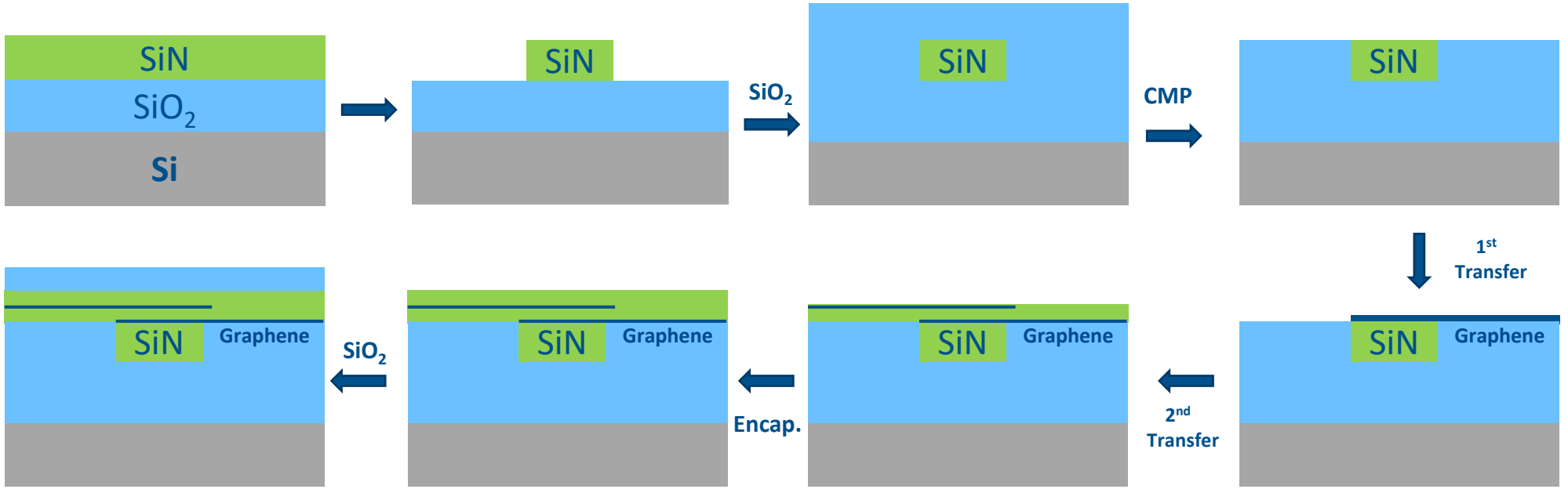


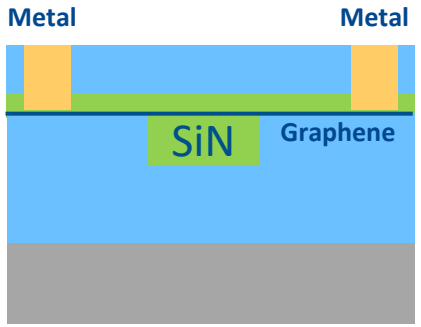




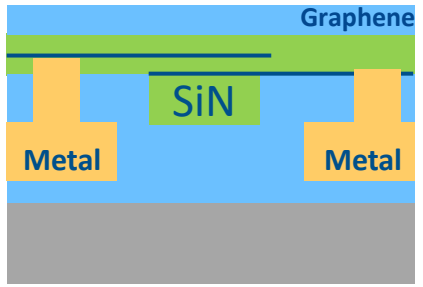


Process Flow: Graphene Modulator



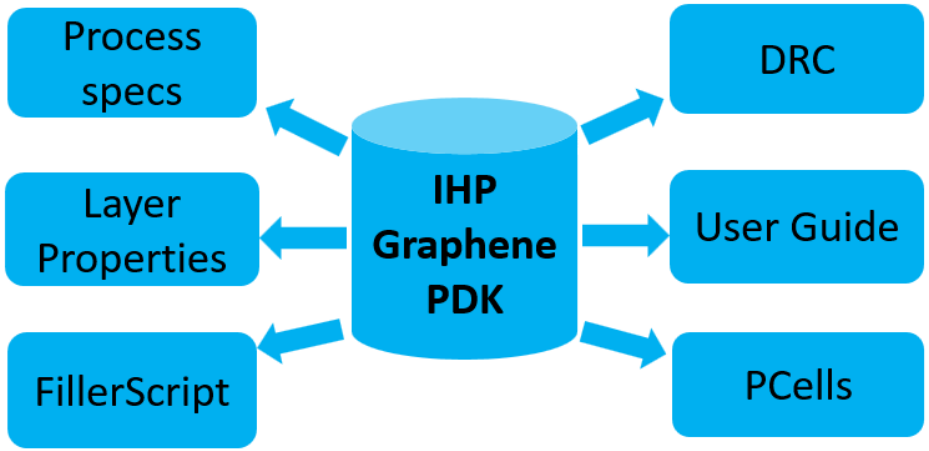


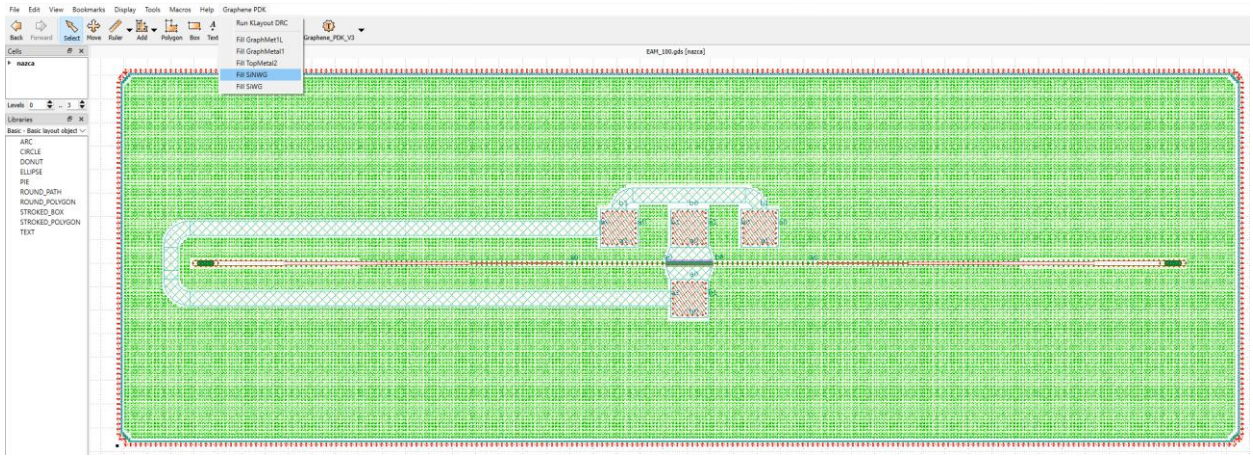
Modulator Type 1

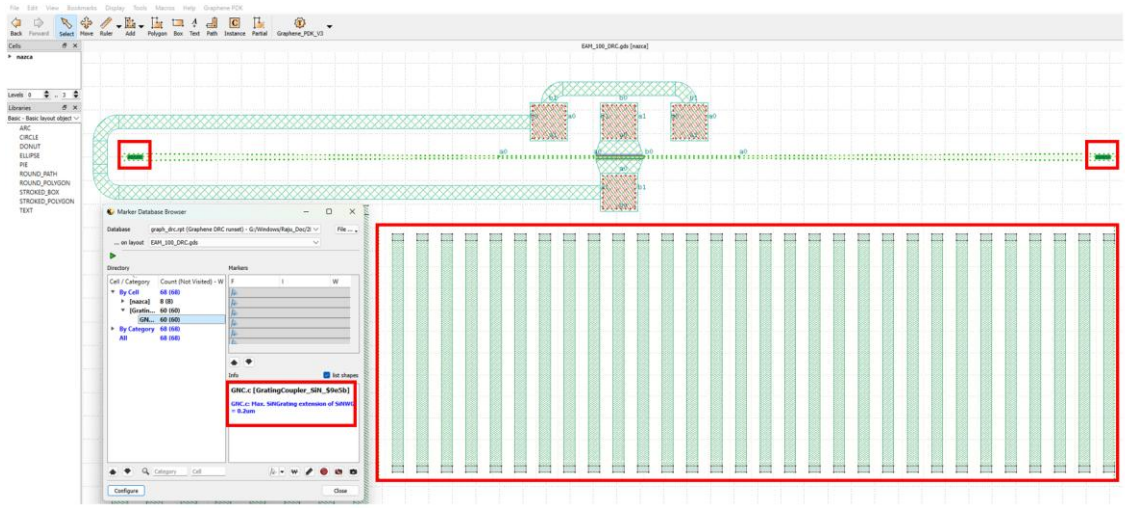


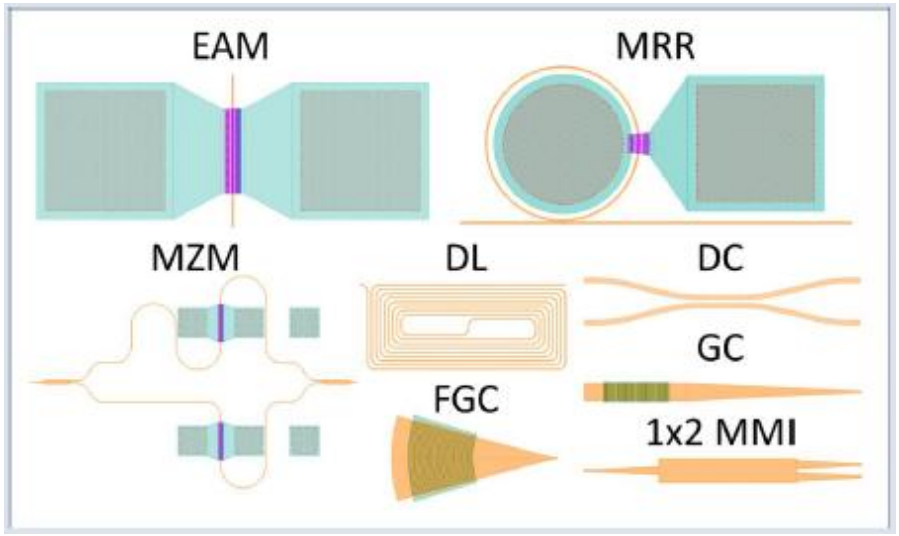
Modulator Type 2

IHP Graphene PDK Overview

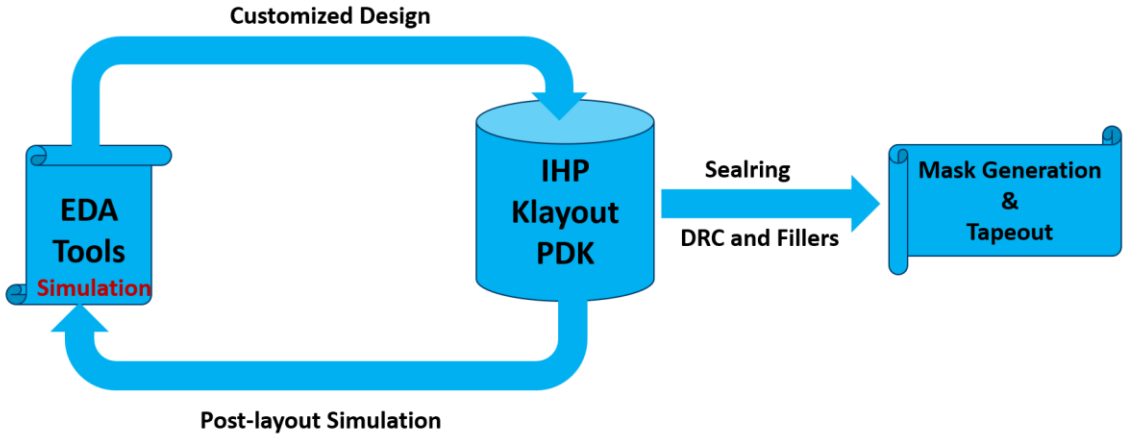


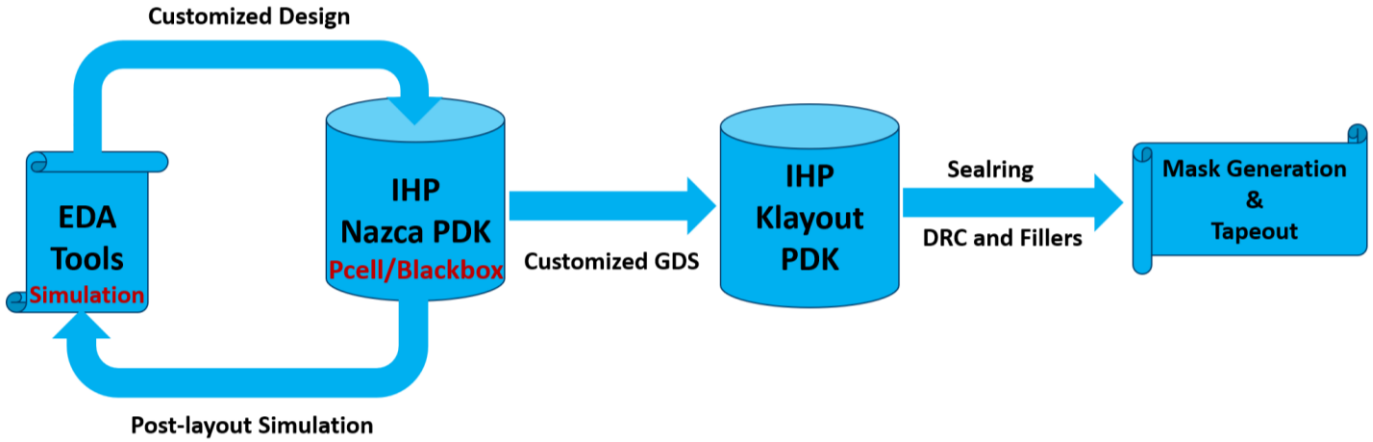






IHP Graphene PDK

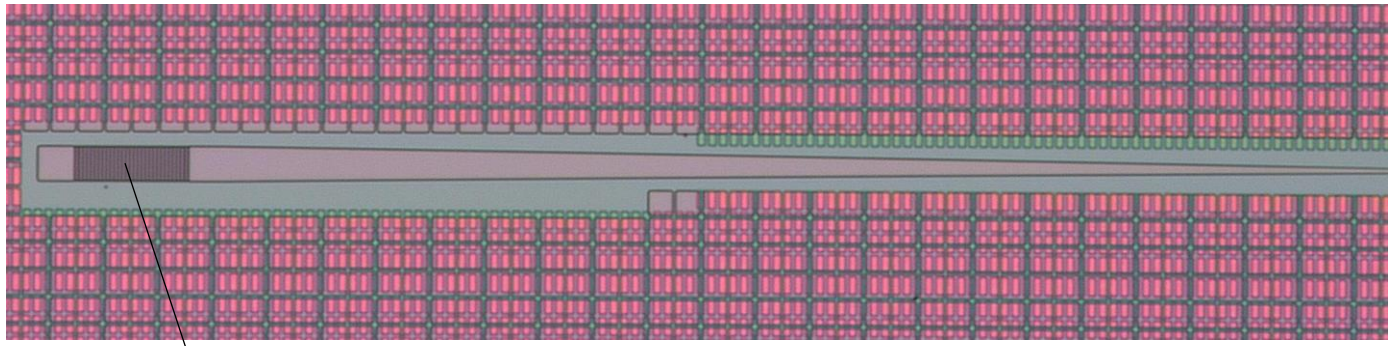


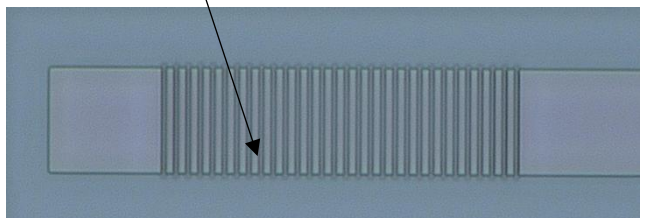


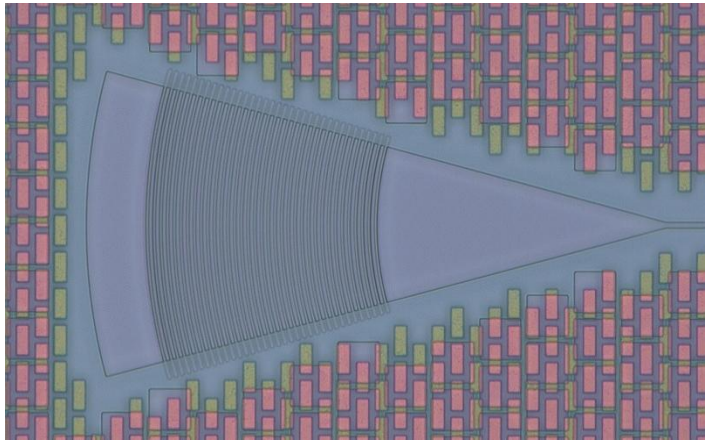
IHP Graphene PDK on Platform :

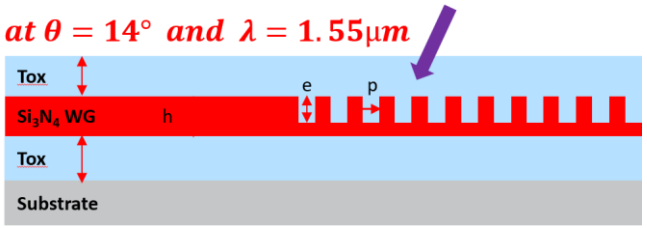
- **Klayout – PDK Available**
- **Nazca – PDK Available**
- **GDS Factory – PDK in Progress**

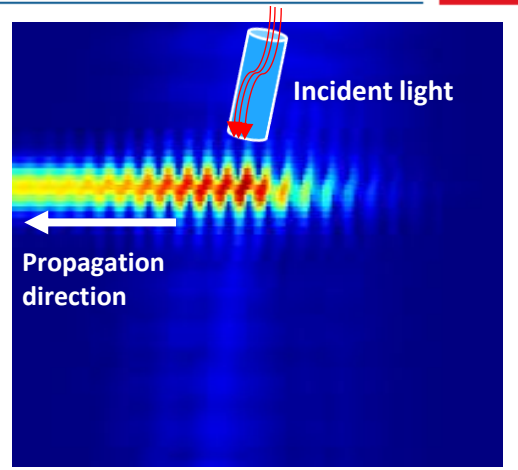
SiN Grating Couplers

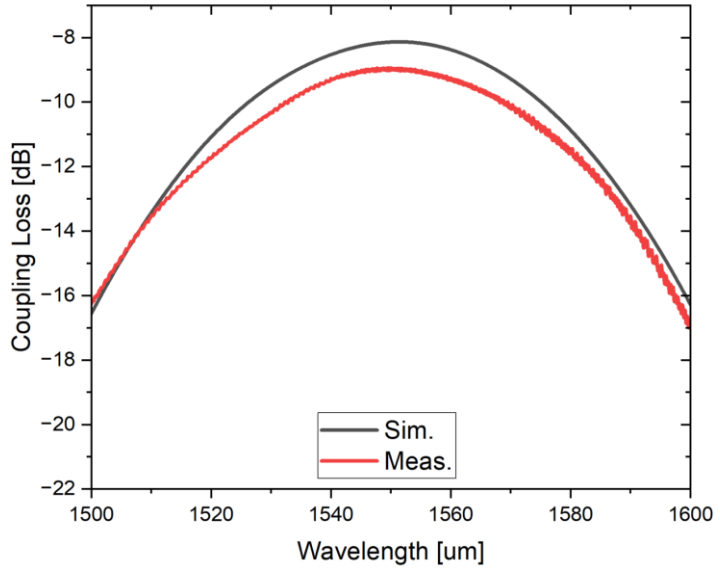




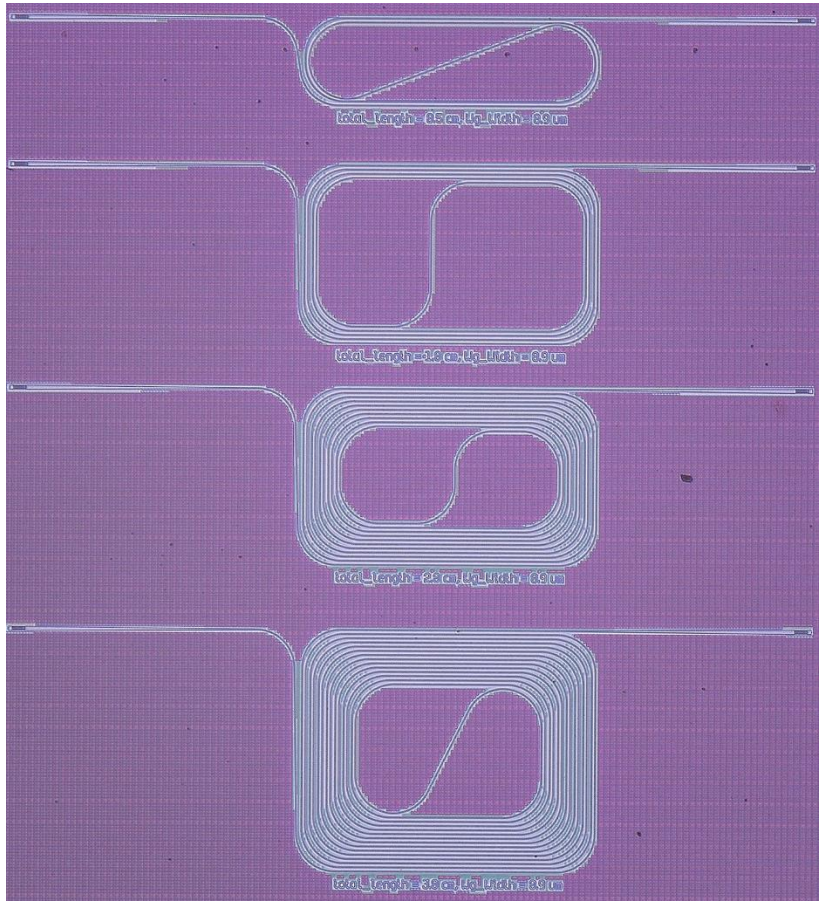


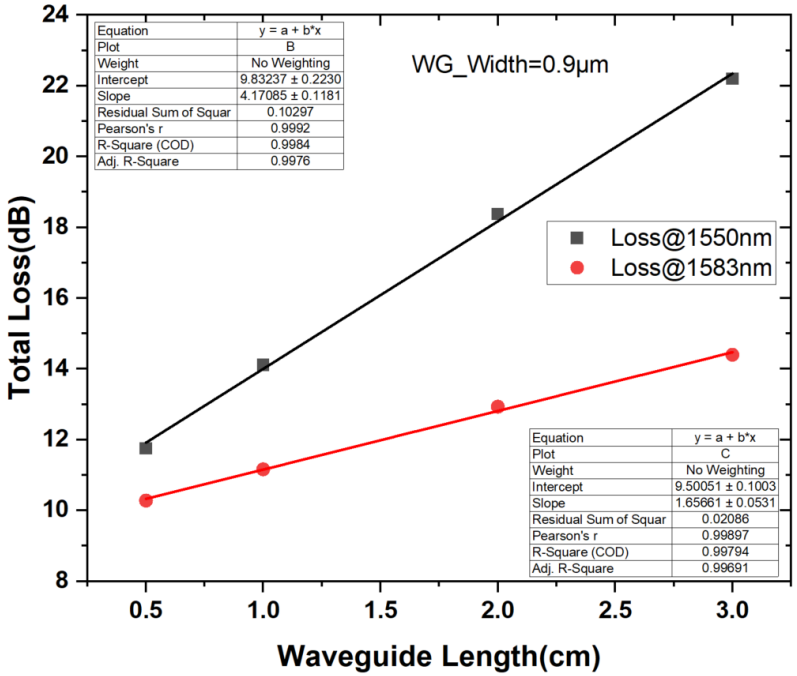






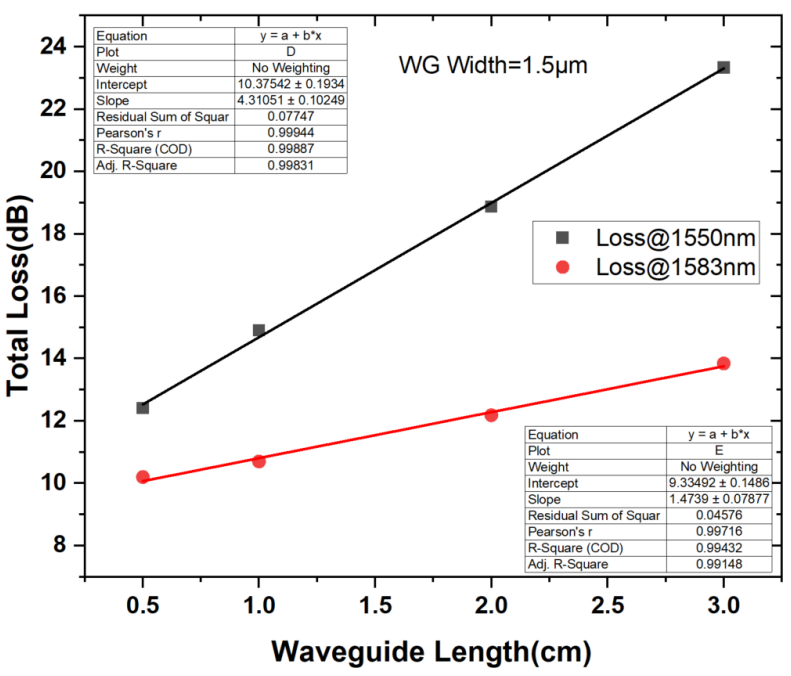
Delay Line for Waveguide Losses





Loss/GC= 4.75 dB@1583nm

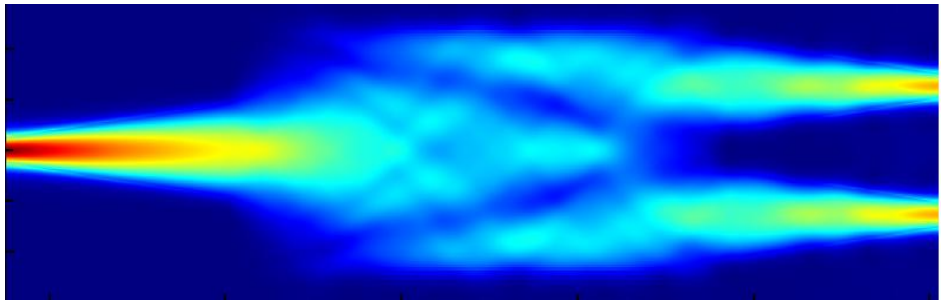
WG Loss@1583nm = 1.65 dB/cm

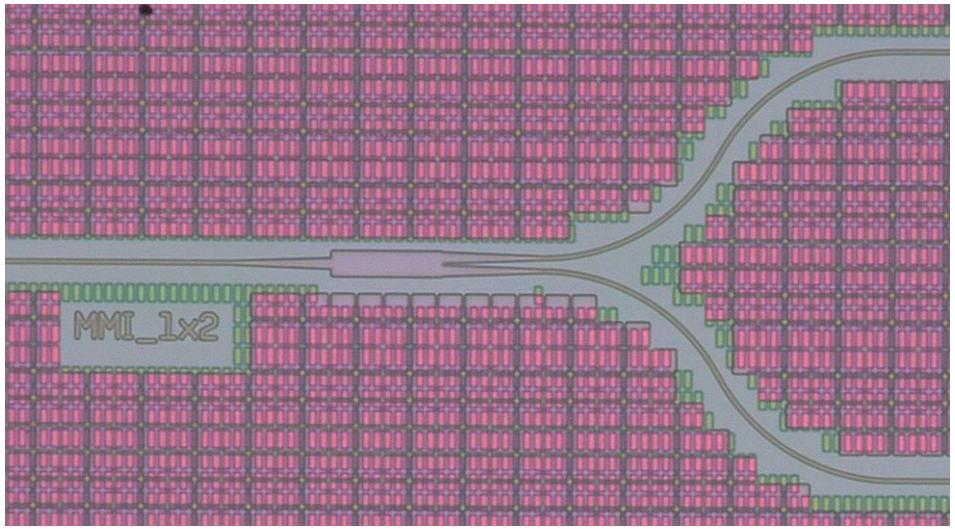


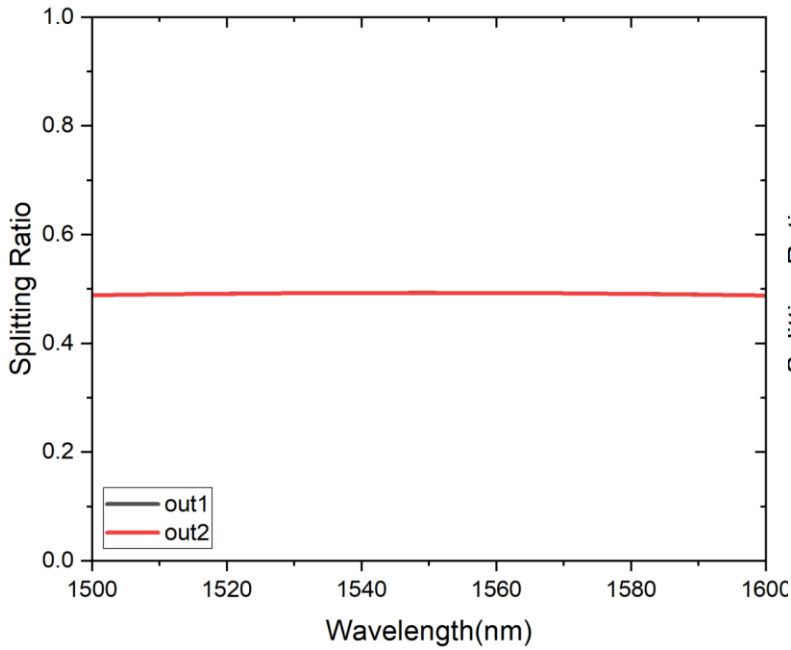
Loss/GC= 4.65 dB@1583nm

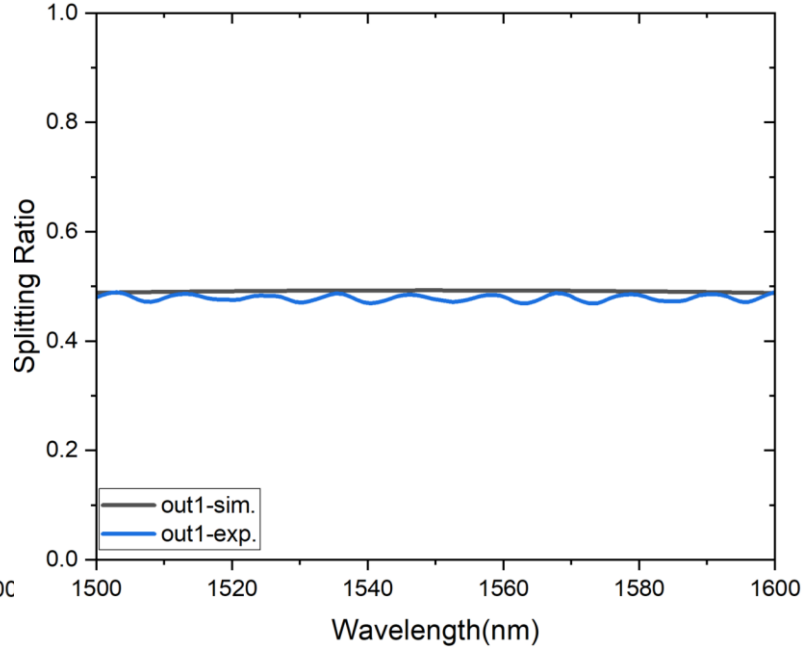
WG Loss@1583nm = 1.47 dB/cm

Multimode Interferometers (1x2)

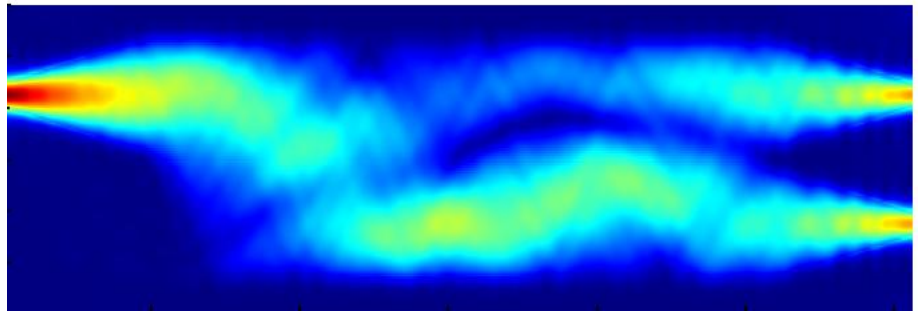


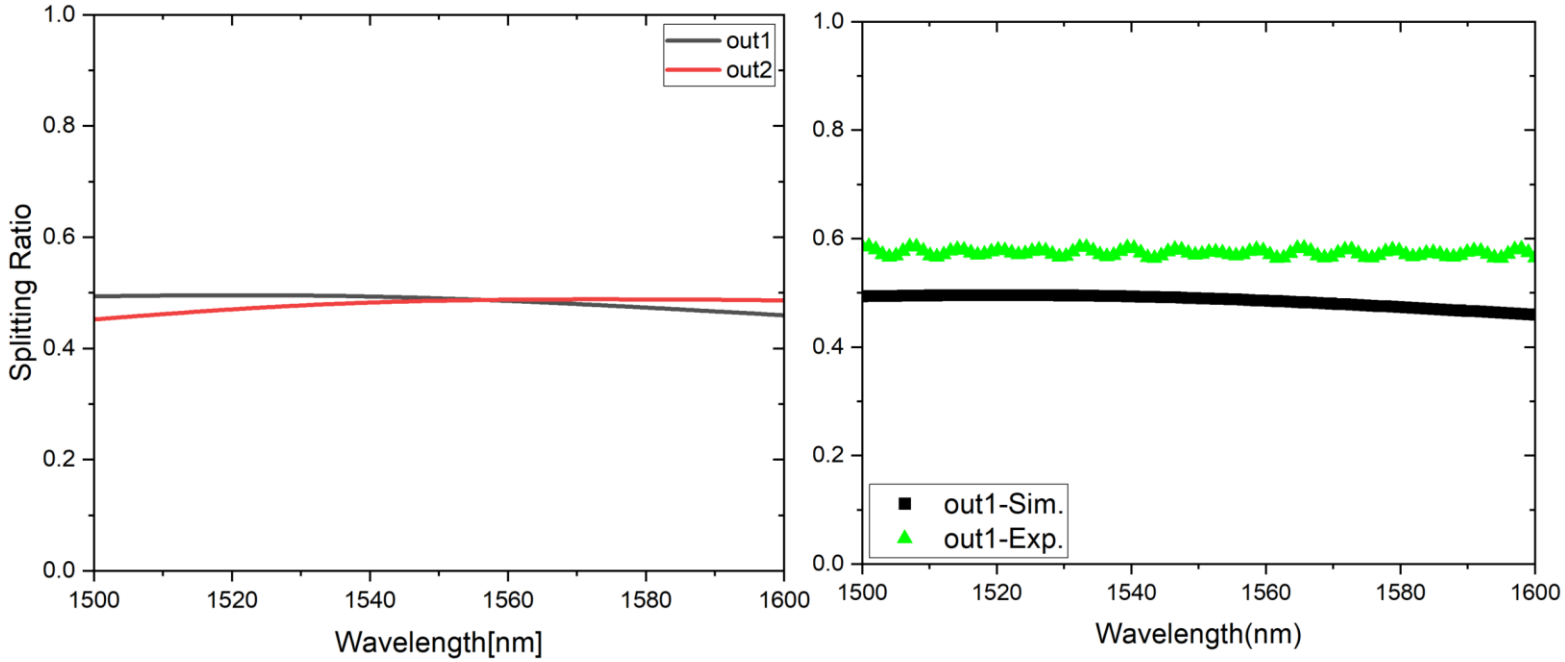


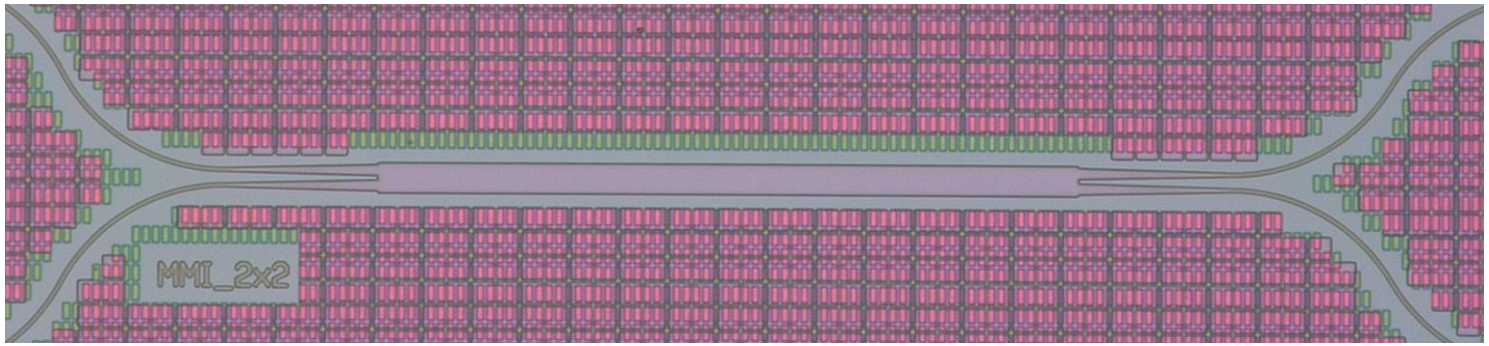




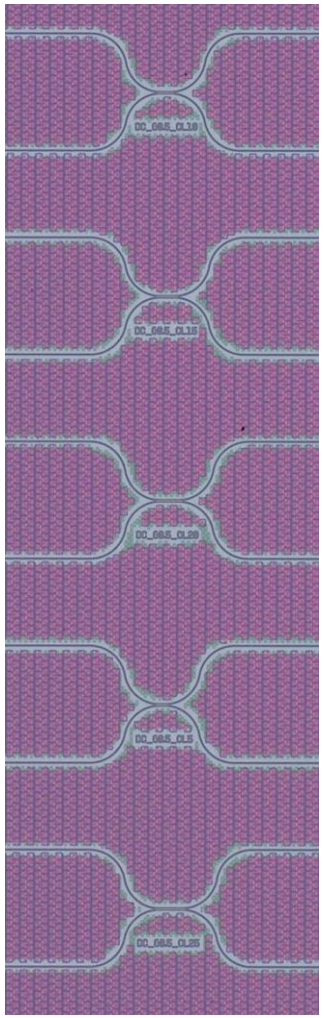
Multimode Interferometers (2x2)

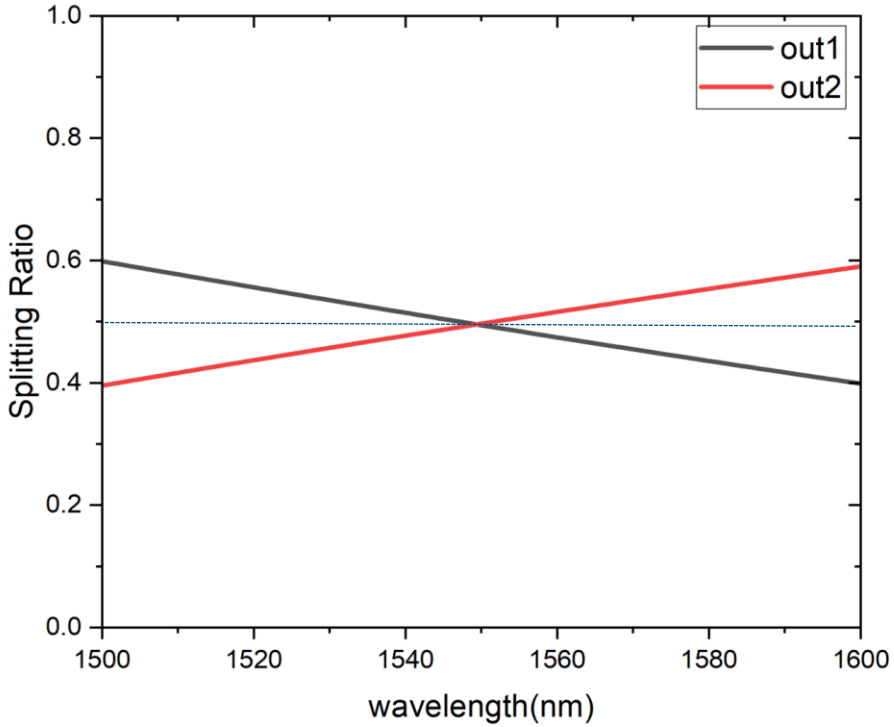


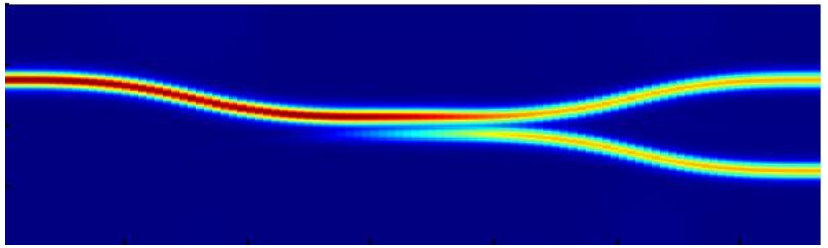




Directional Couplers

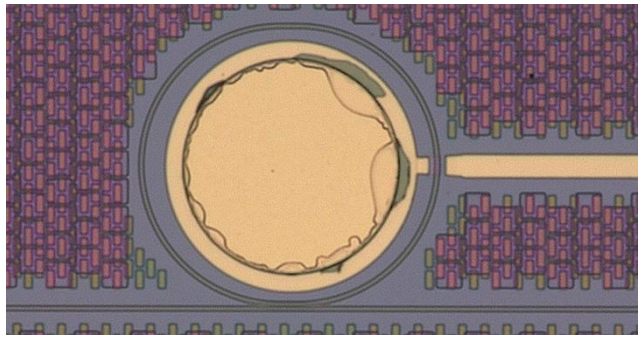


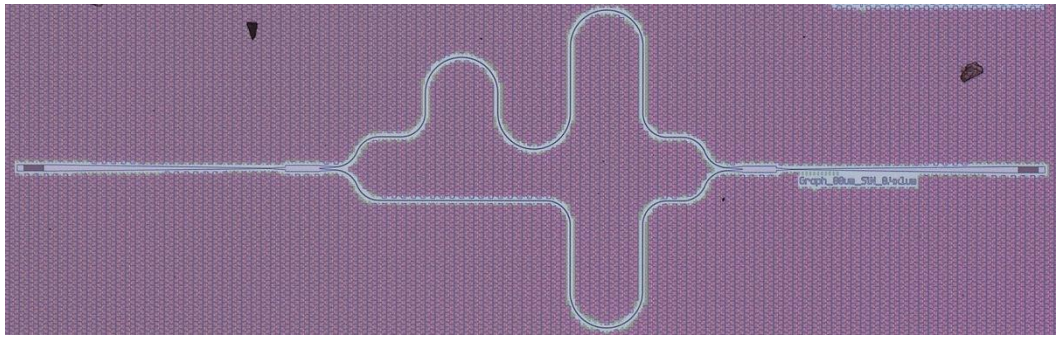


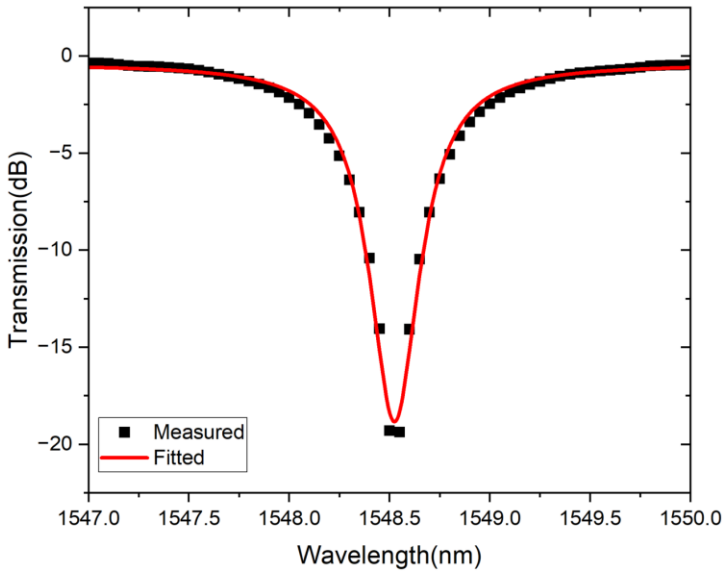


CL	SR (Sim.)	SR (Exp.)
5	0.90/0.10	0.88/0.12
10	0.75/0.25	0.77/0.23
15	0.65/0.35	0.65/0.35
20	0.50/0.50	0.50/0.50
25	0.65/0.35	0.64/0.36

Ring Resonator and MZM

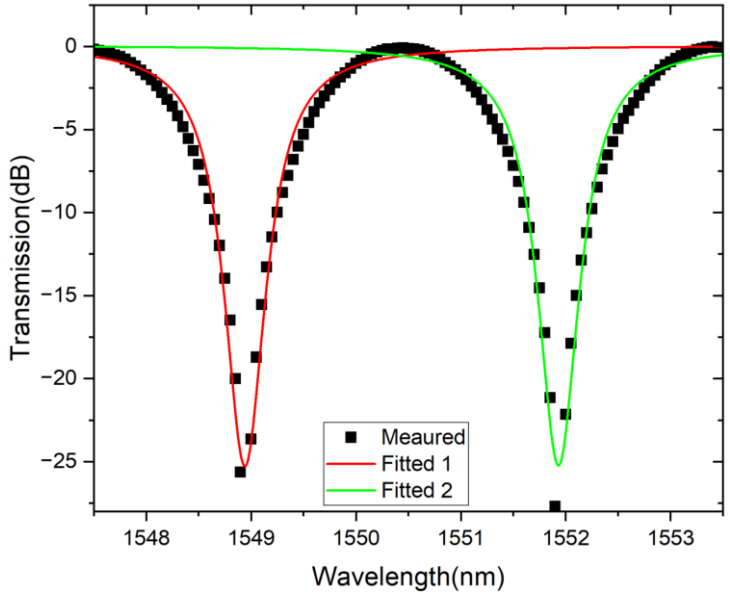






FSR=6nm

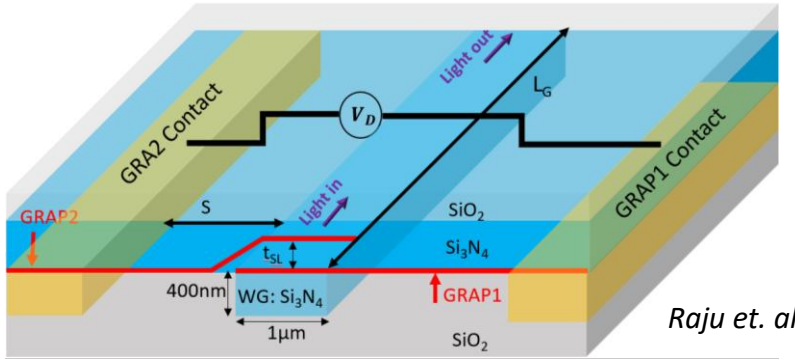
ER=20dB



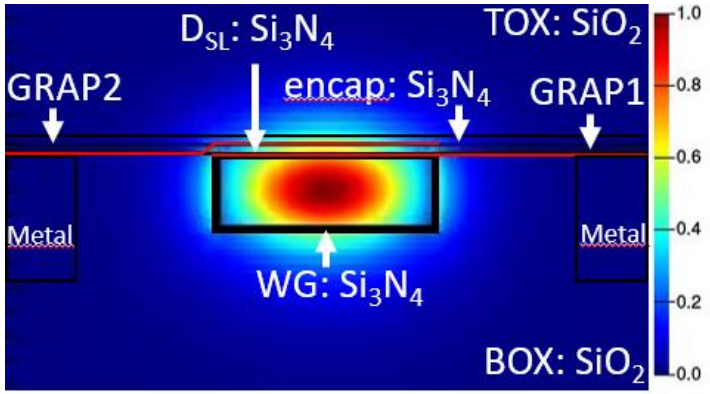
FSR=3nm

ER=25dB

Graphene Electro-absorption Modulator

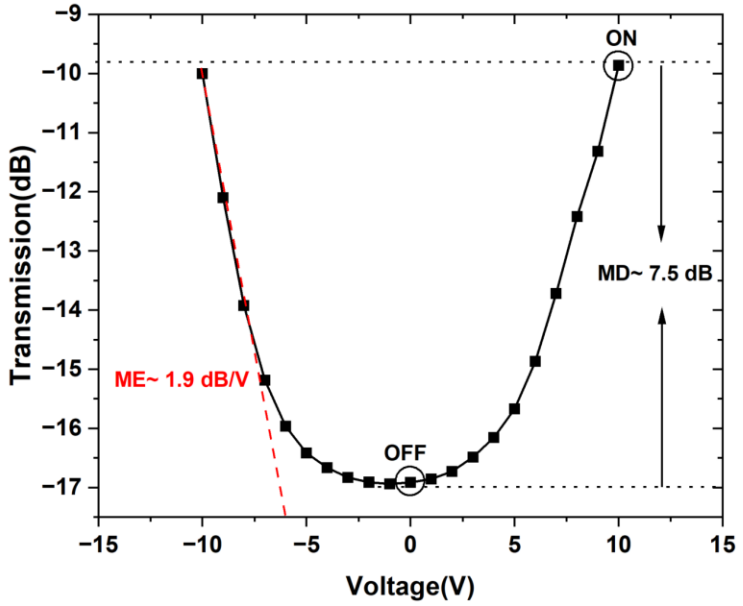


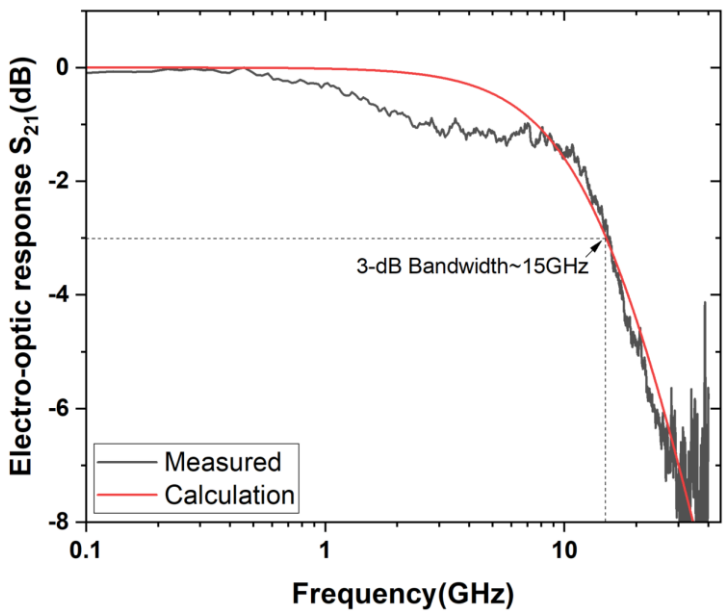
Raju et. al. IPC025

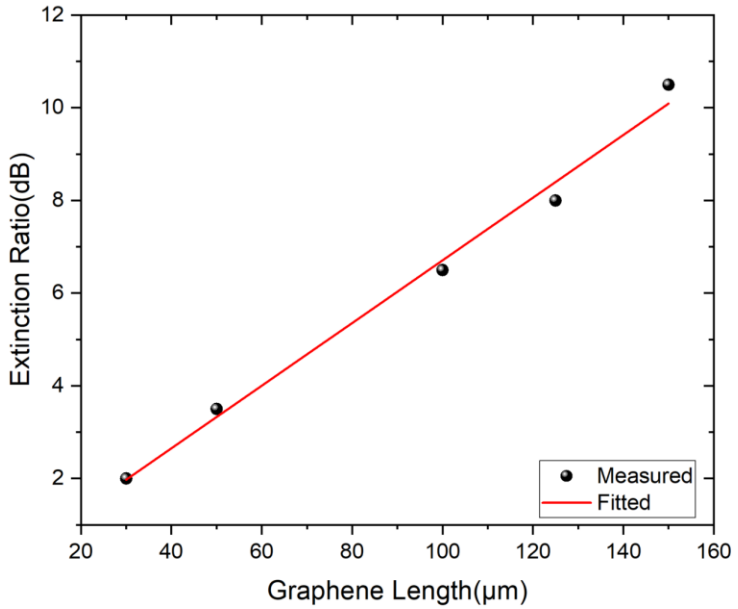


- **Modulation Efficiency = 1.9 dB/V**
- **Bandwidth = 15 GHZ @100µm**
- **ER and ME reach upto 10.5 dB and 2.9 dB/V**

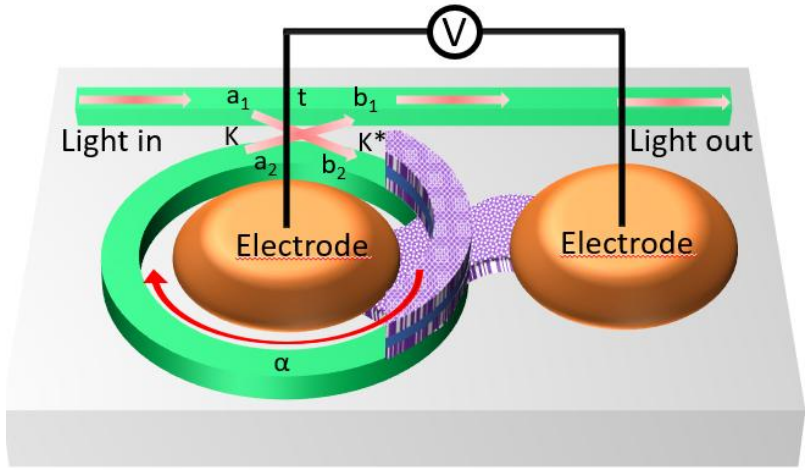
(Paper under review)

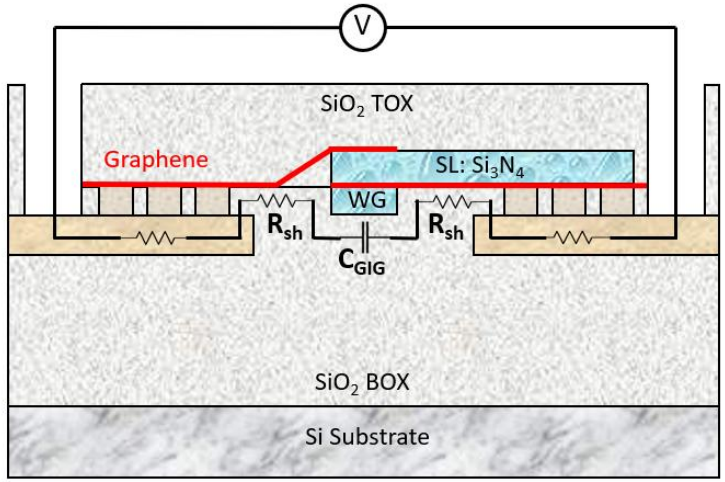


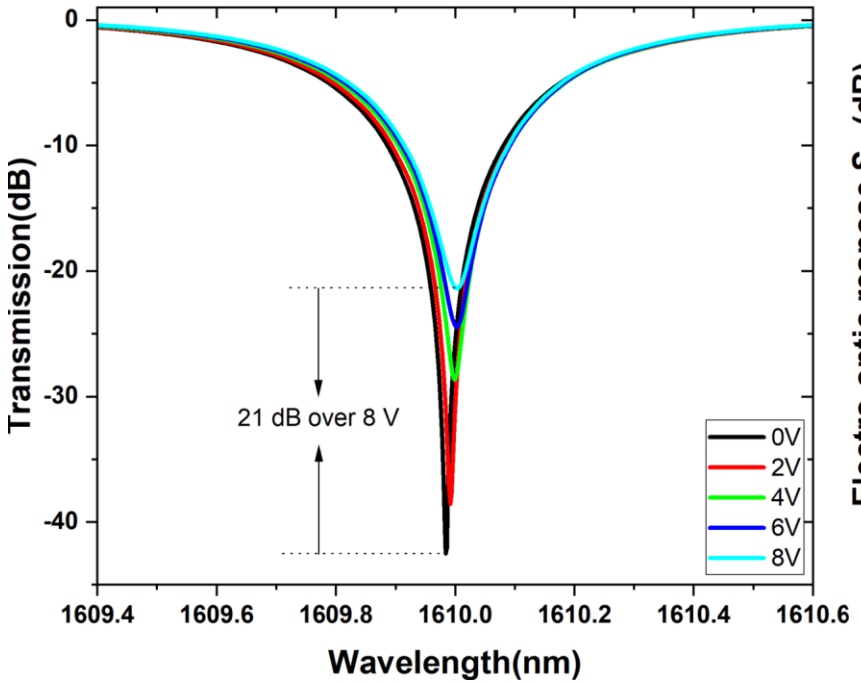


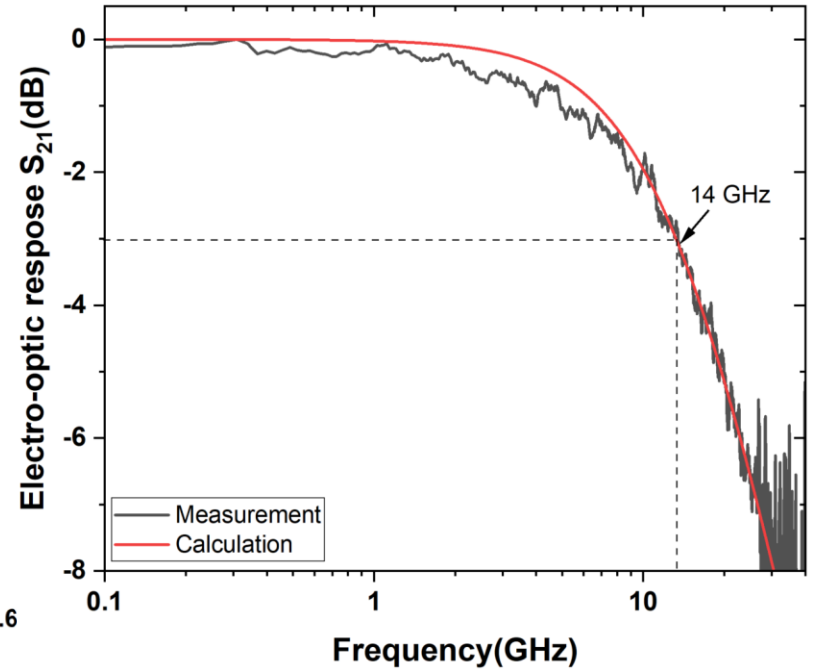


Graphene Ring Modulator









Monolithically Integrated on 200 mm Pilot Line

Modulation Efficiency 2.6 dB/V and Bandwidth 14 GHz

(Paper in Progress)

Thank you for your attention!

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