Quantum transport in dual-channel InAs/InP/GaAsSb core-shell nanoscale devices

and

Graphene/unltrathin-Si_3N_4 heterostructure device

Sedighe Salimian

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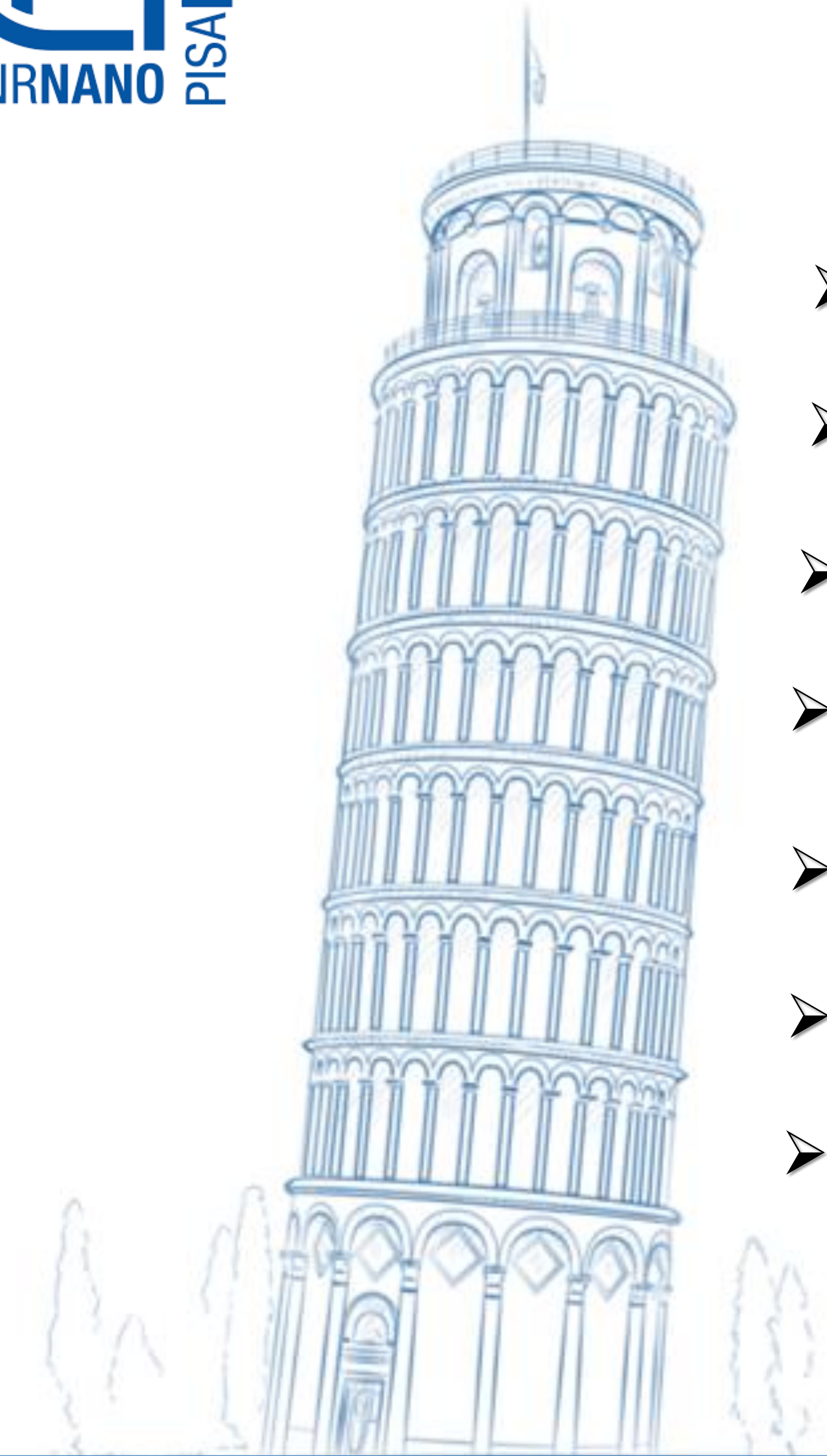

- ***Where we are..***
- ***Experimental results***
- ***Device Structure***
- ***InAs/InP/GaSb core-dual shell NWs; application***
- ***InAs/GaSb heterostructure; application***
- ***Broken-gap; Negative differential resistance***
- ***III-V heterostructures NW with broken gap***

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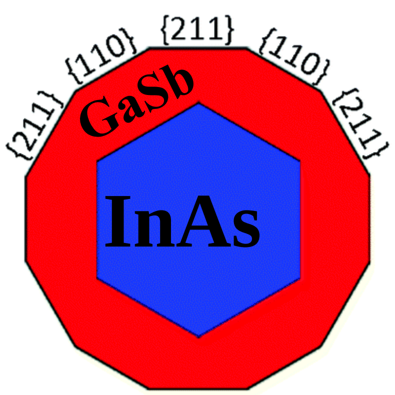
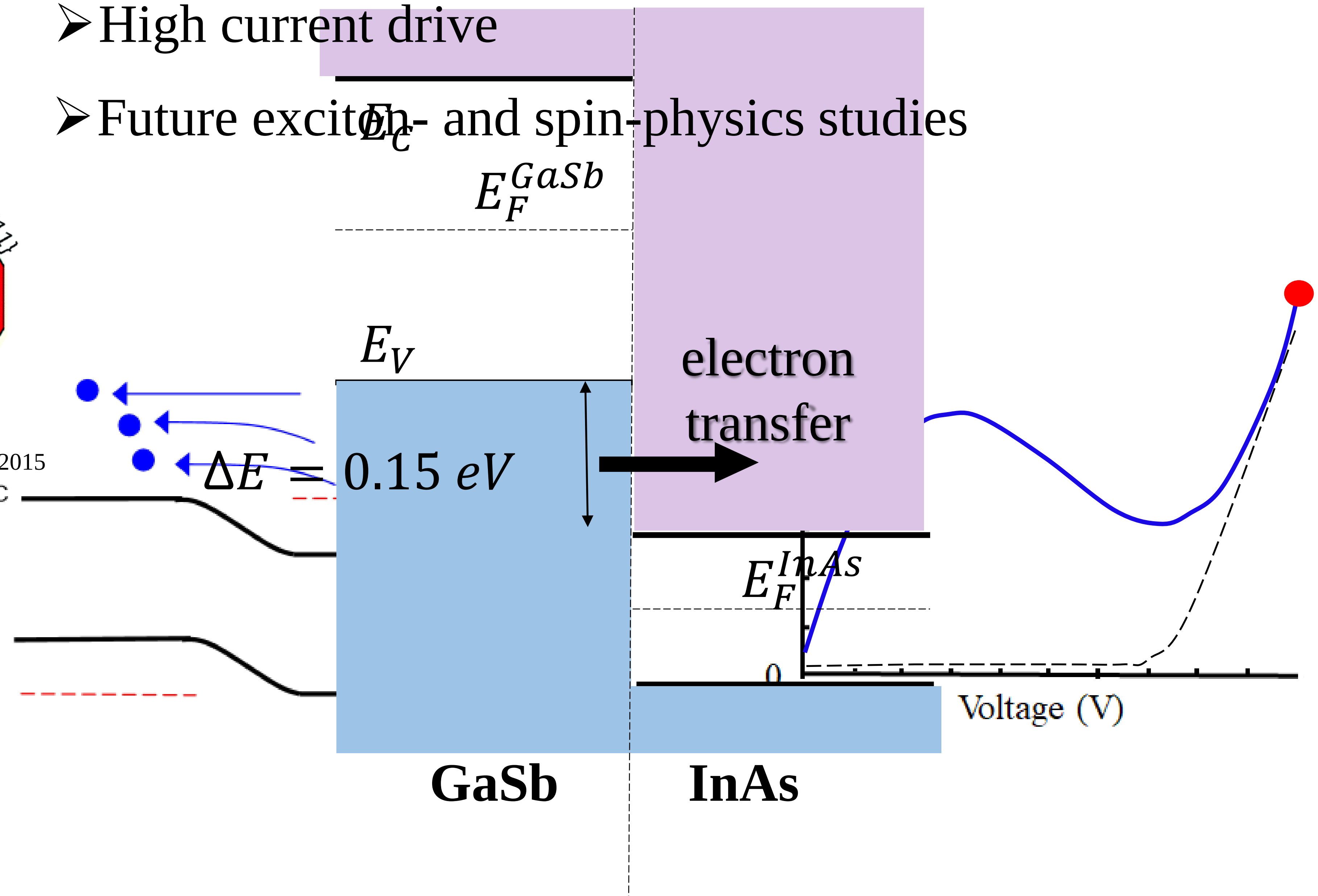
Broken gap: Negative differential resistance

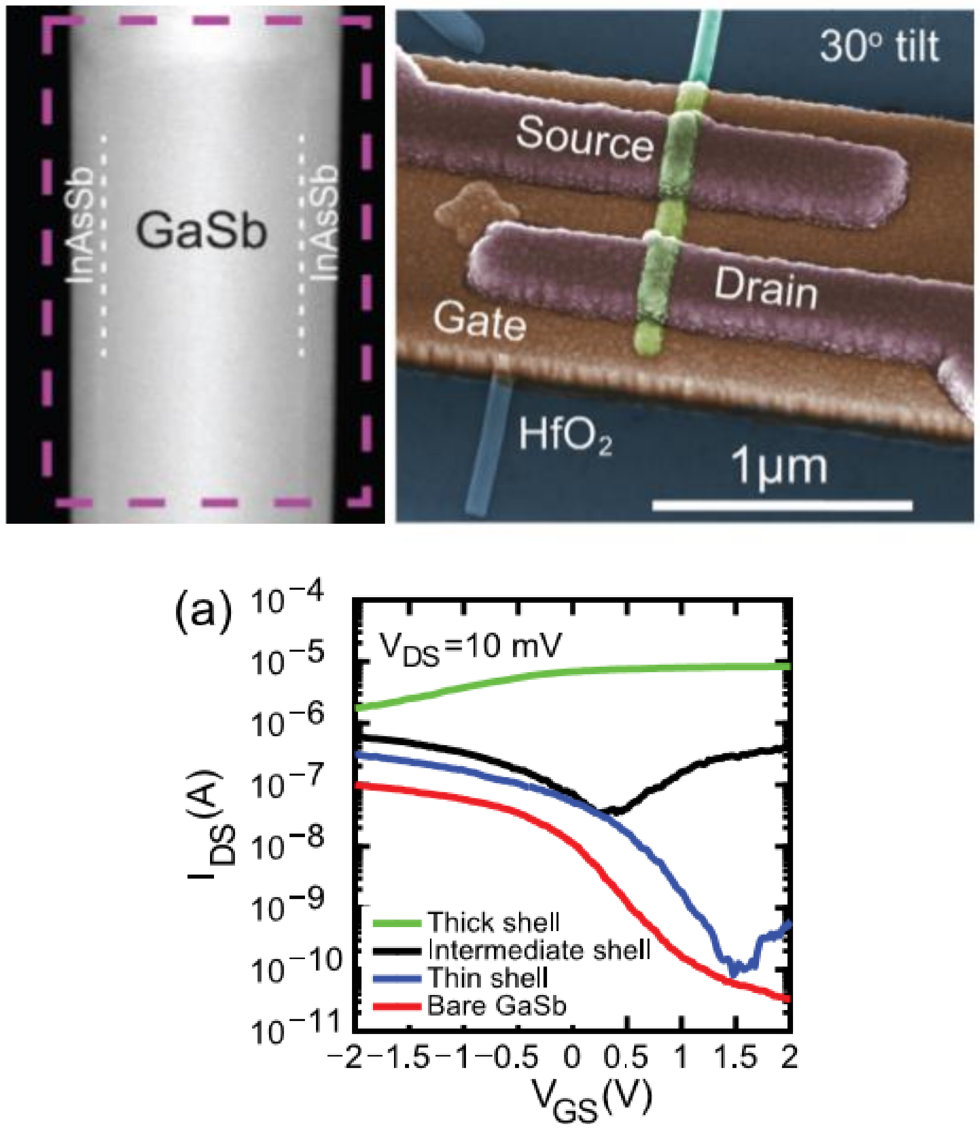
- Inter-band tunneling without a barrier
- High current drive
- Future exciton- and spin-physics studies



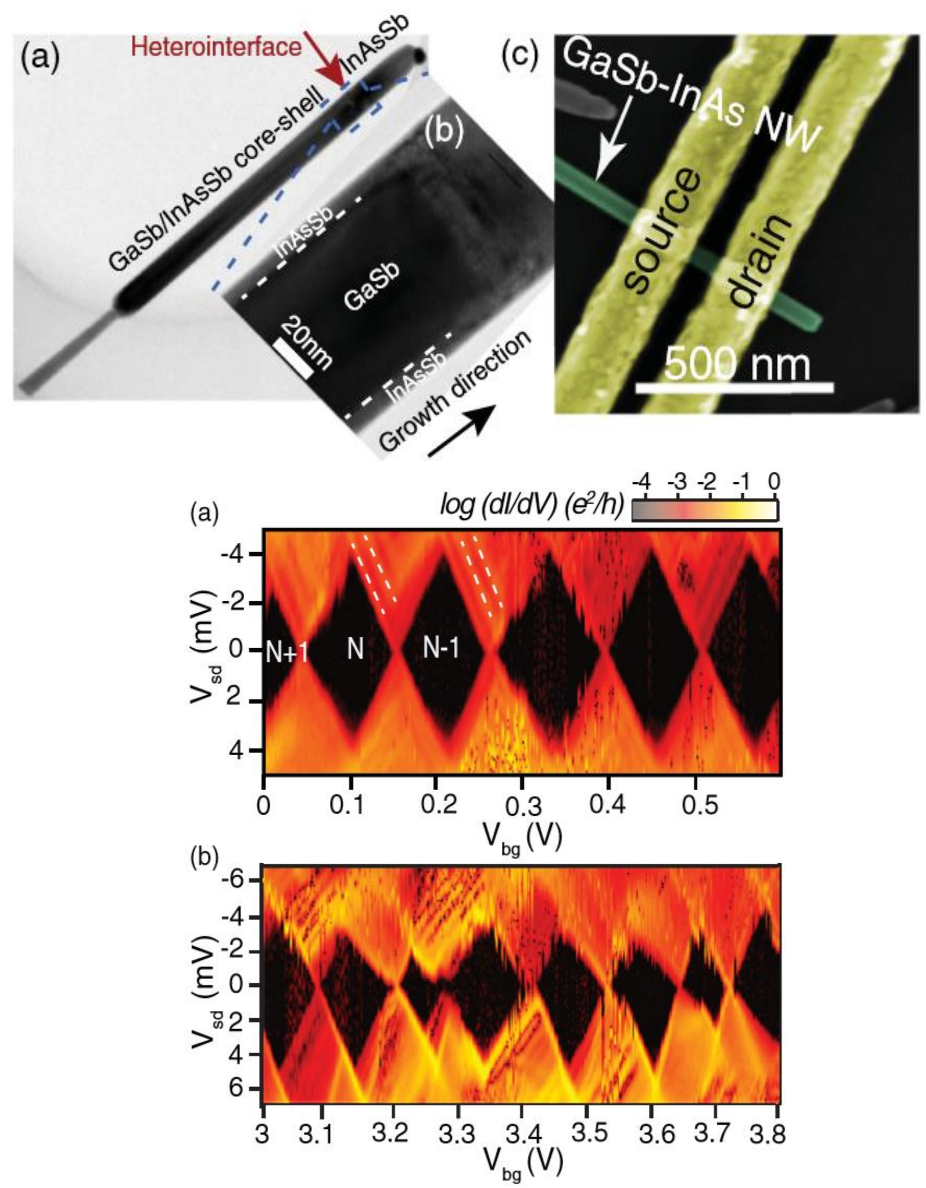
T. Reiger et al. Nanoscale, 2015



III-V heterostructures NW ;application



Appl. Phys. Lett. 101, 103501 (2012)



Phys. Rev. B 91, 161301(R) (2015)

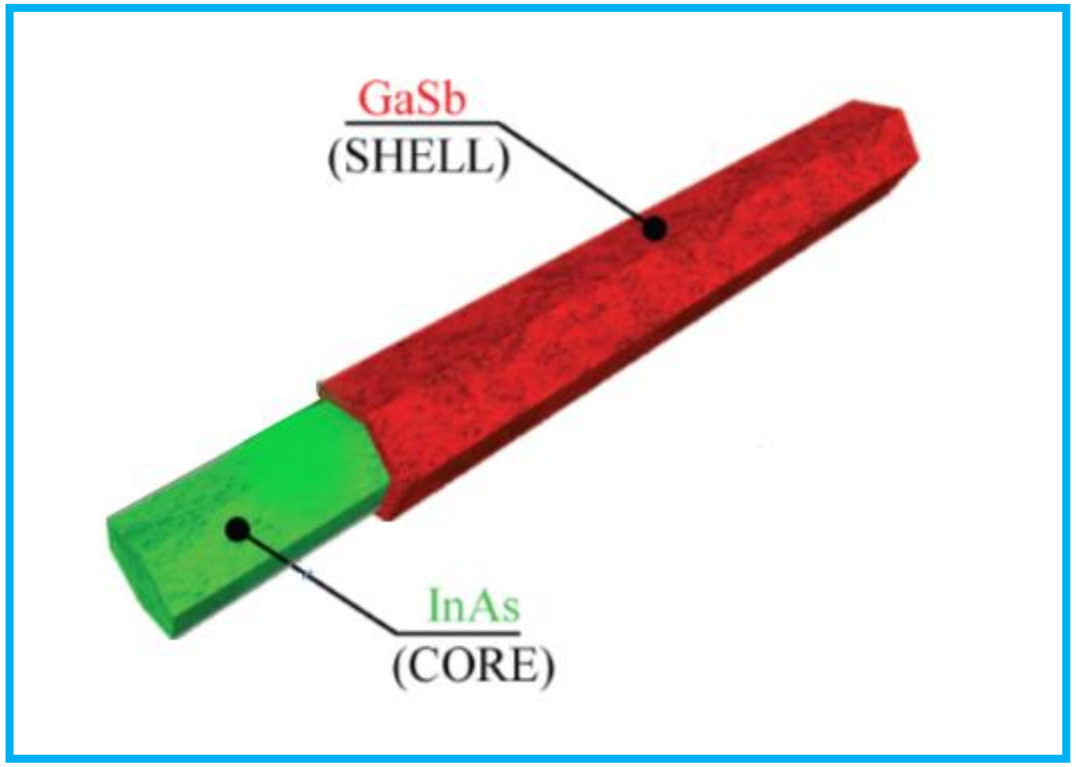
NANO LETTERS

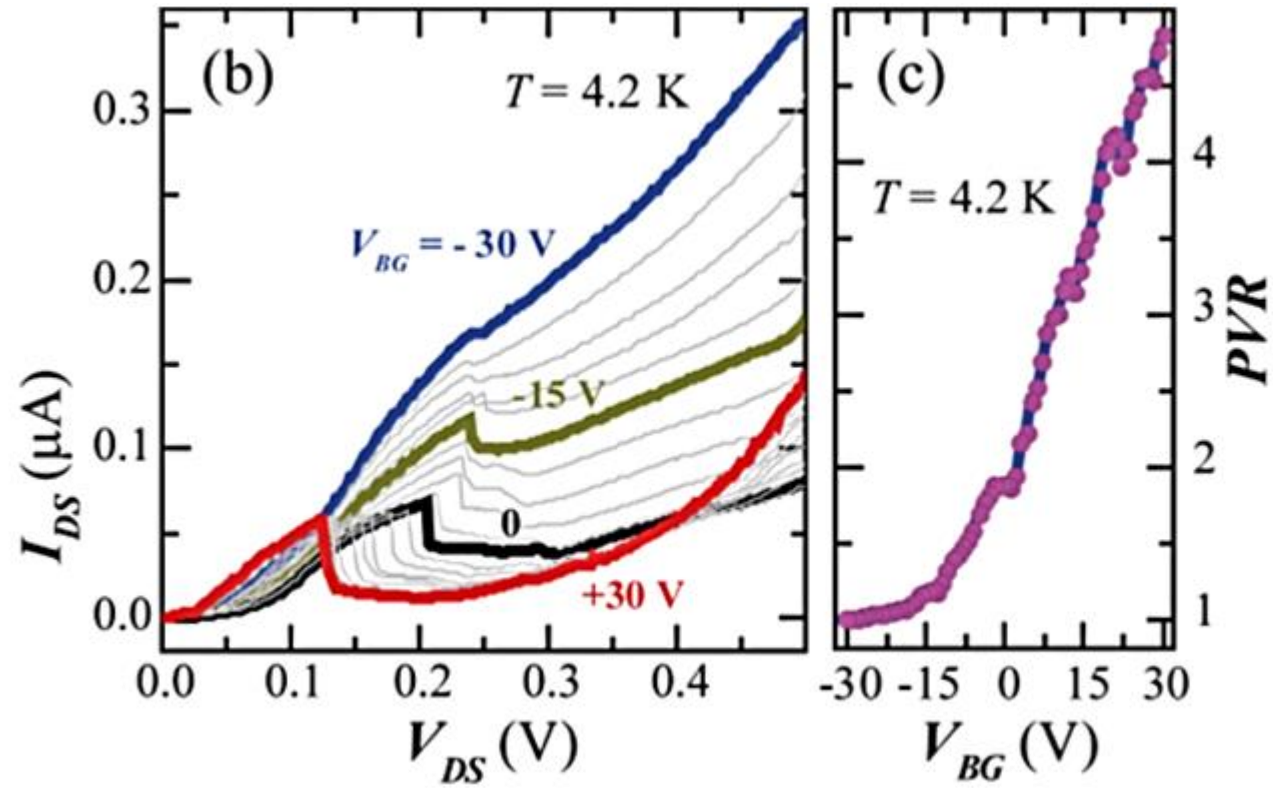
Letter

pubs.acs.org/NanoLett

Tunable Esaki Effect in Catalyst-Free InAs/GaSb Core–Shell Nanowires

M. Rocci,*,† F. Rossella,*,† U. P. Gomes,† V. Zannier,† F. Rossi,‡ D. Ercolani,† L. Sorba,† F. Beltram,† and S. Roddaro*,†





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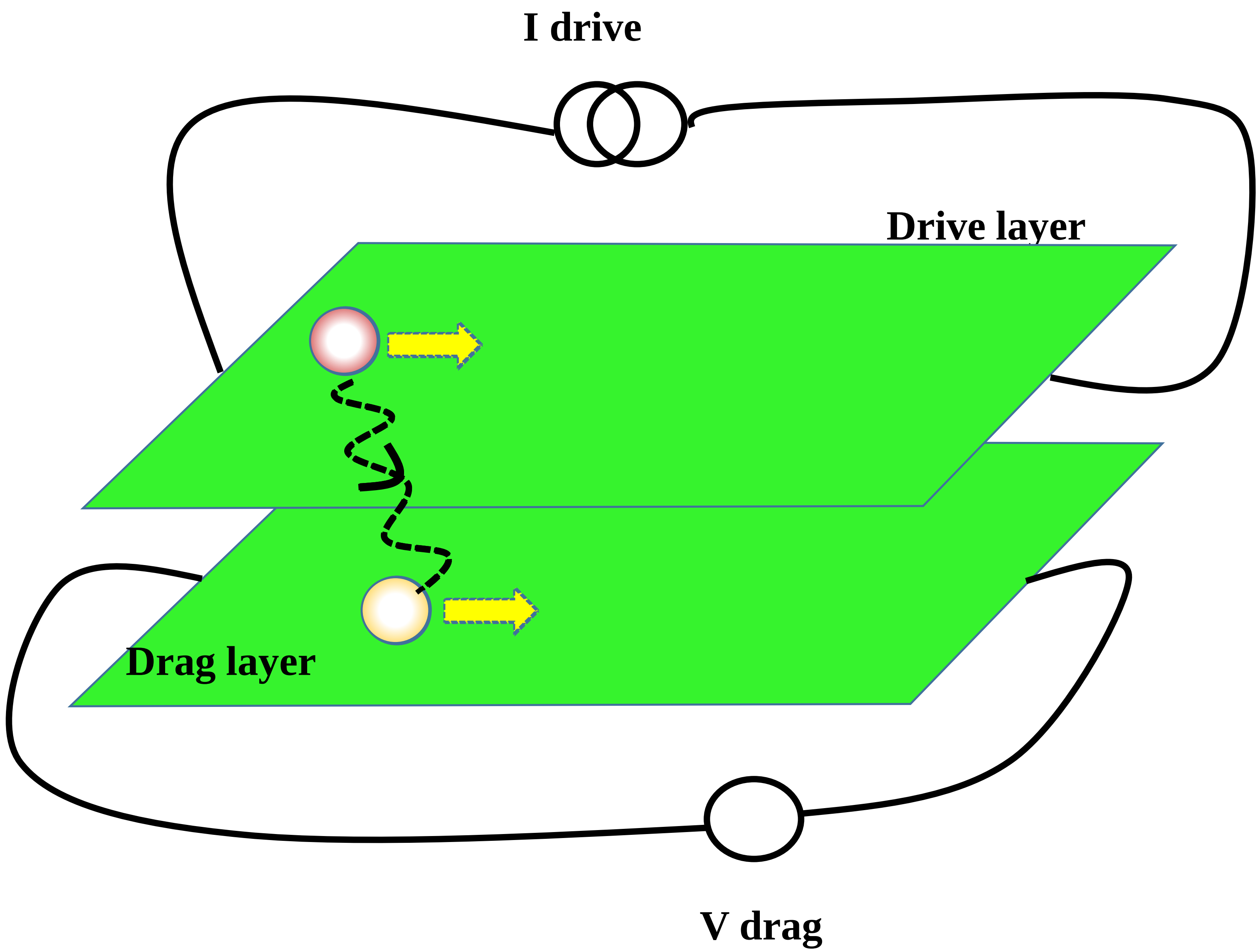
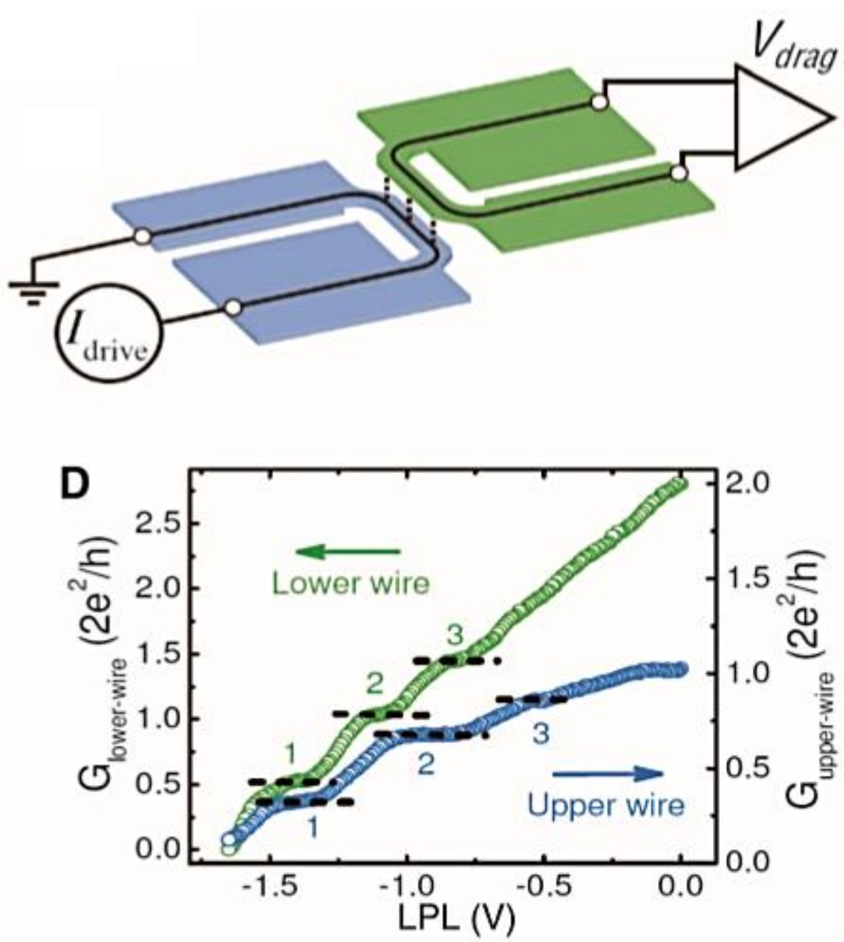
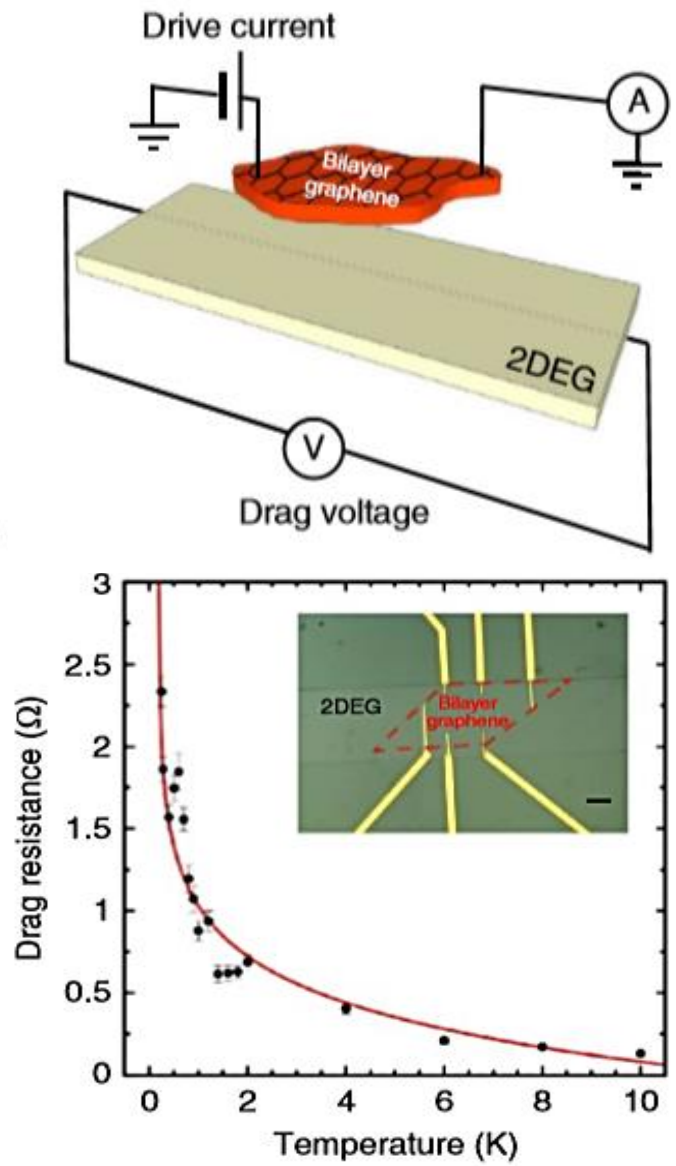
Coulumb drag systems



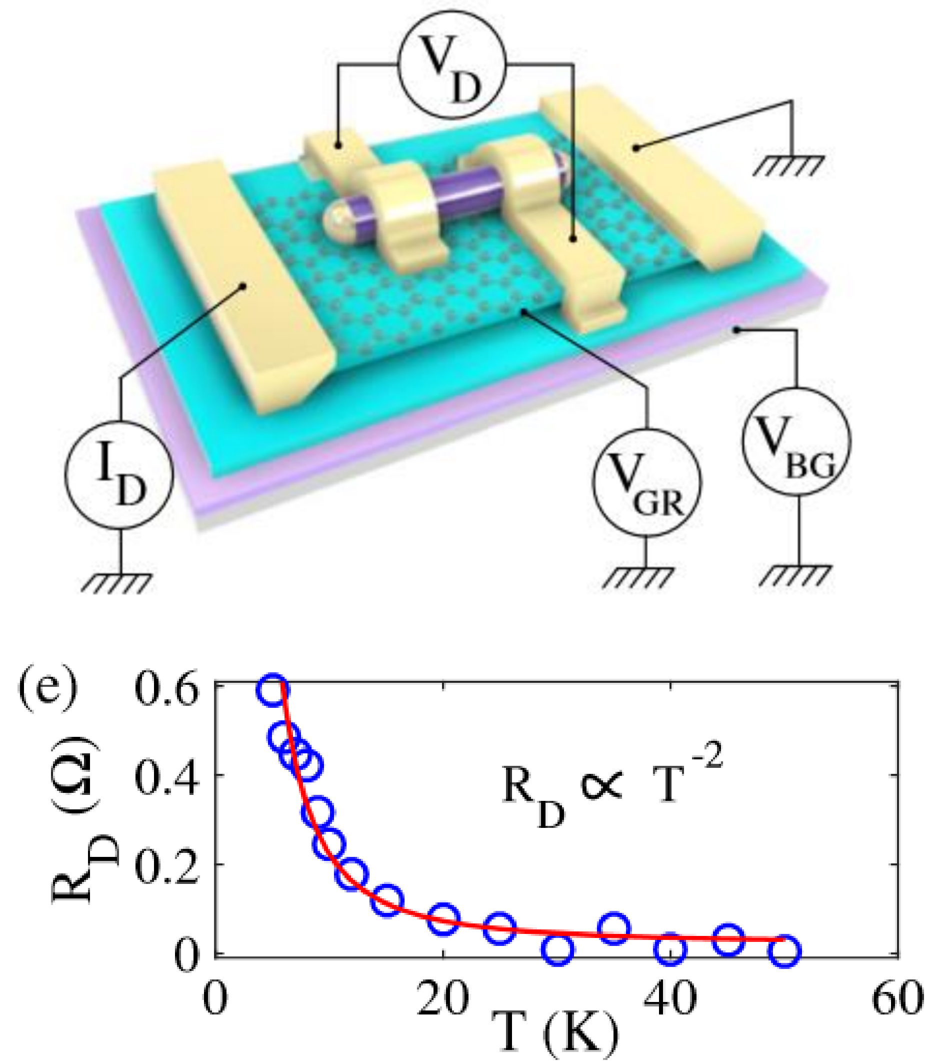
Coulumb drag systems



Sience, 343, 632 (2014)



Nature Com. 5, 5824 (2014)



Phys. Rev. Let. 124, 116803 (2020)

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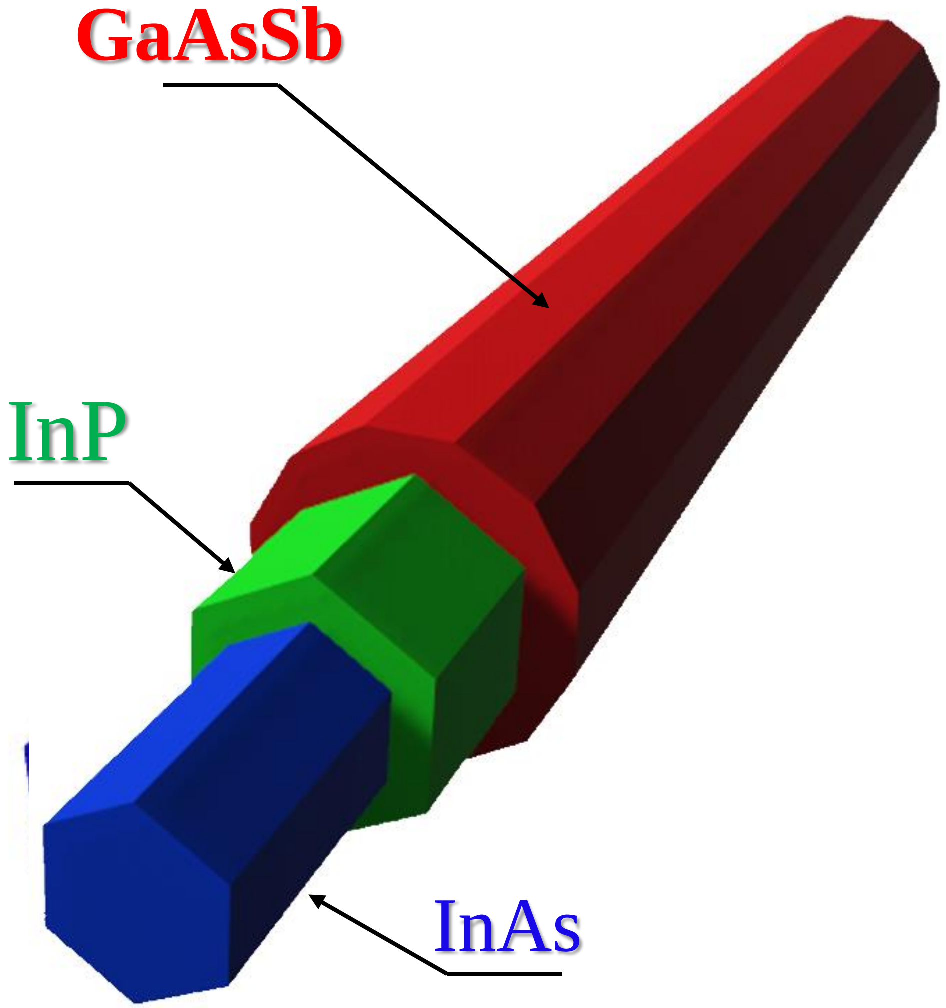
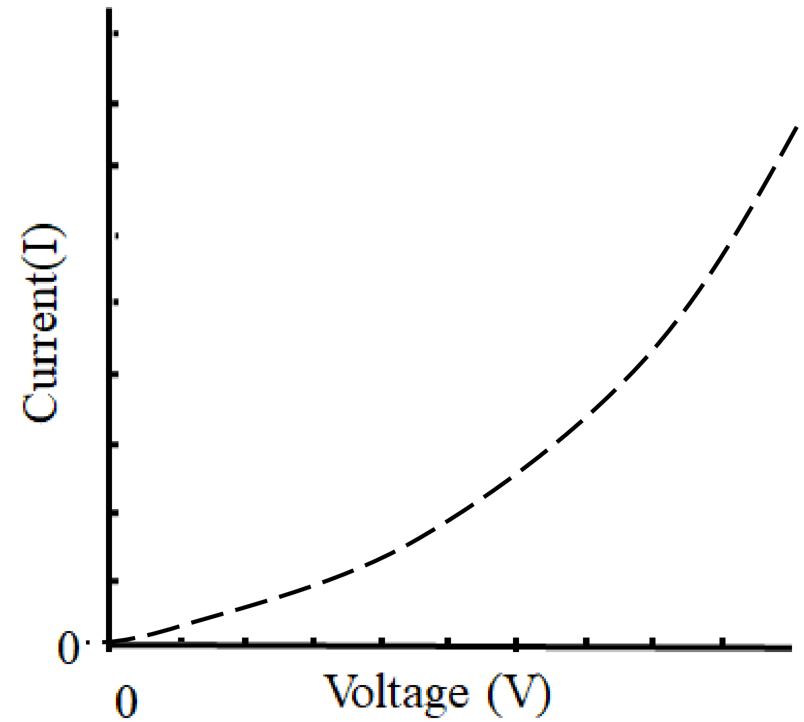
NW heterostructures with radial symmetry

- Decoulple charge carriers
- Impact of InP barrier
- Dominated charge carrier in each channel.



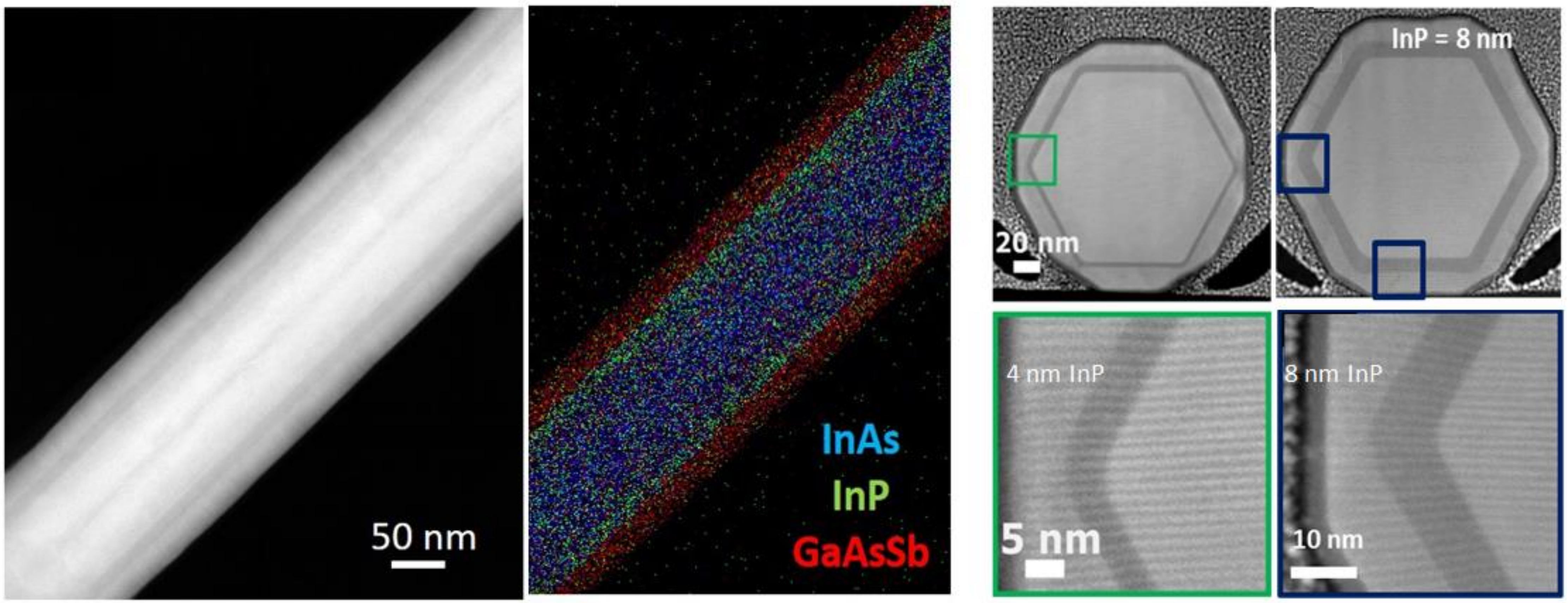


M. Rocci, et al. Nanoletter (2016)

CRYSTAL GROWTH & DESIGN
pubs.acs.org/crystal
Article

Growth and Strain Relaxation Mechanisms of InAs/InP/GaAsSb Core-Dual-Shell Nanowires

Omer Arif, Valentina Zannier,* Ang Li, Francesca Rossi, Daniele Ercolani, Fabio Beltram, and Lucia Sorba



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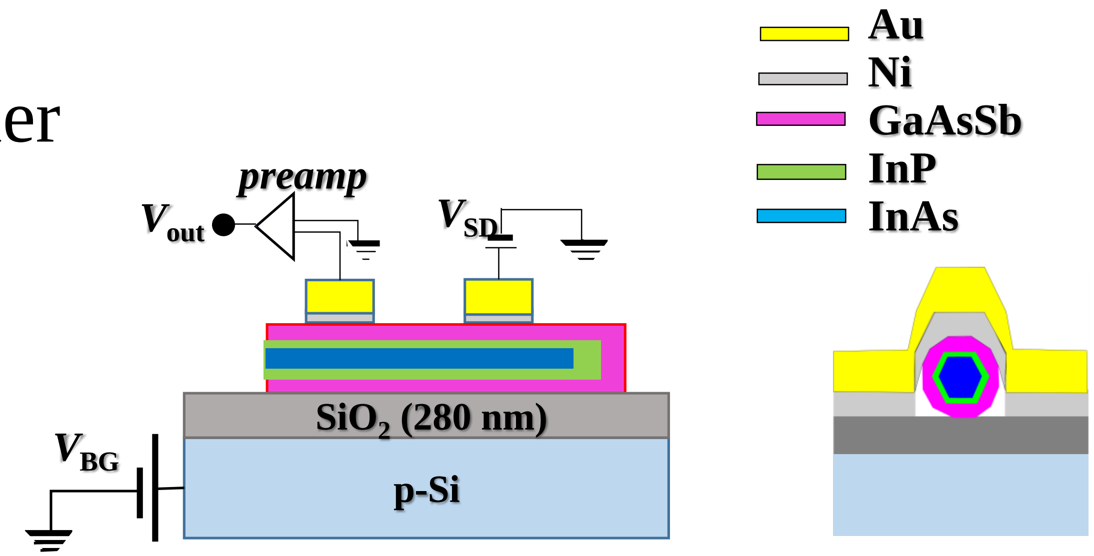
Electrical transport

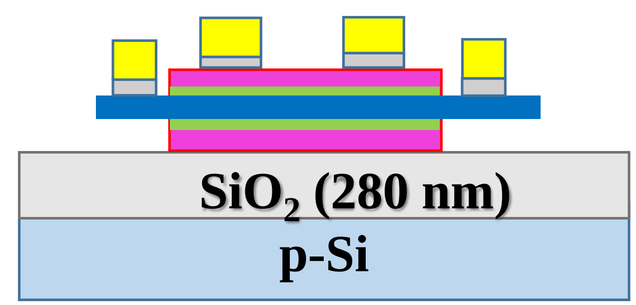
➢Shell-Shell configuraion

Finding the practical thickness of InP barrier

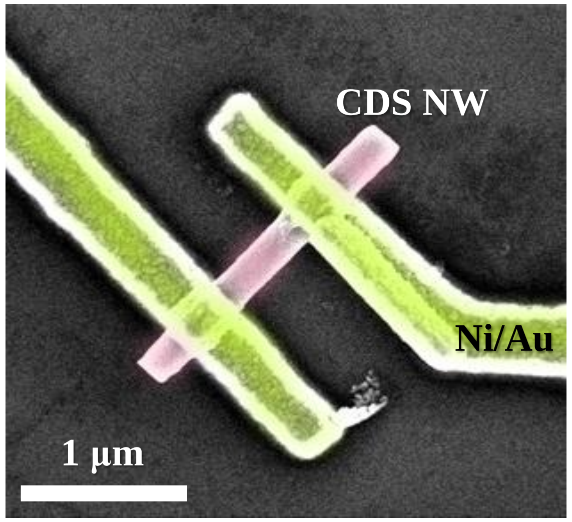


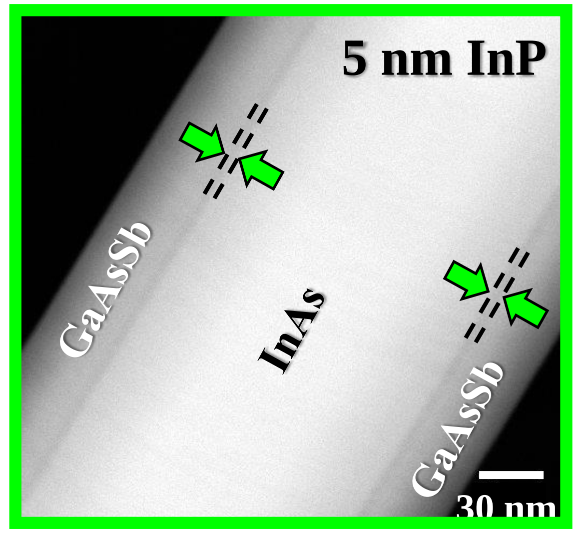
➢Multi-terminal core-shell devices

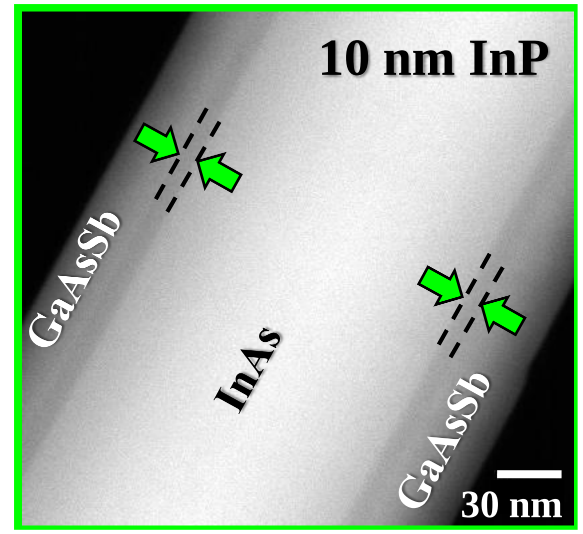
Studying the impact of InP barrier

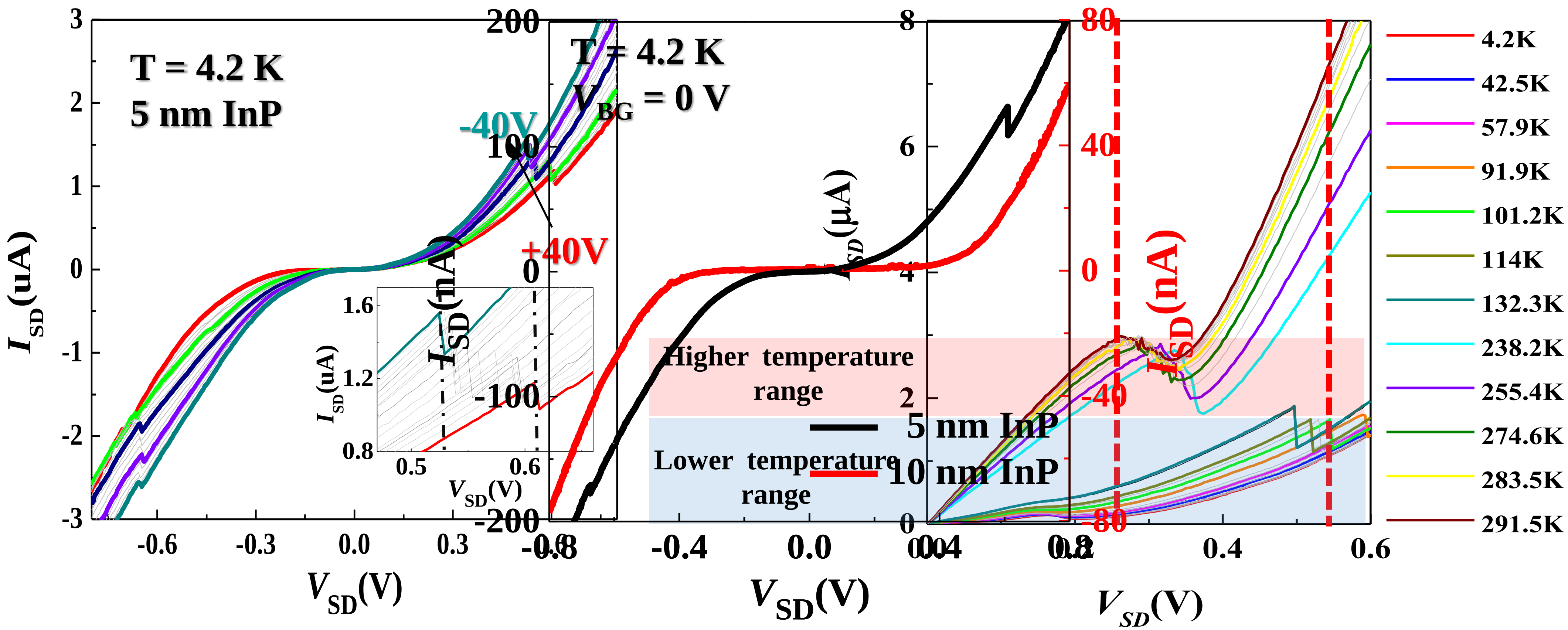


Shell-Shell configuration



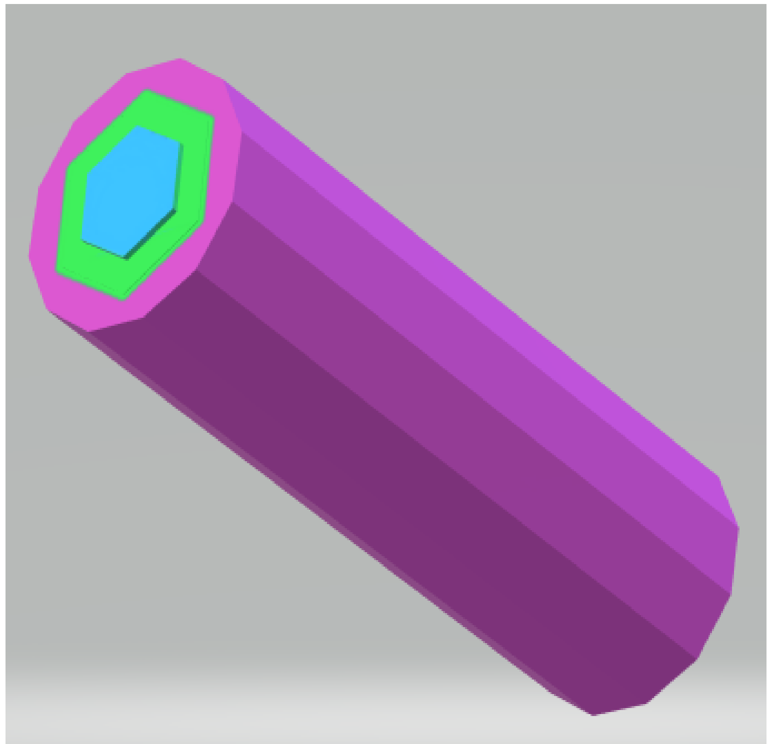




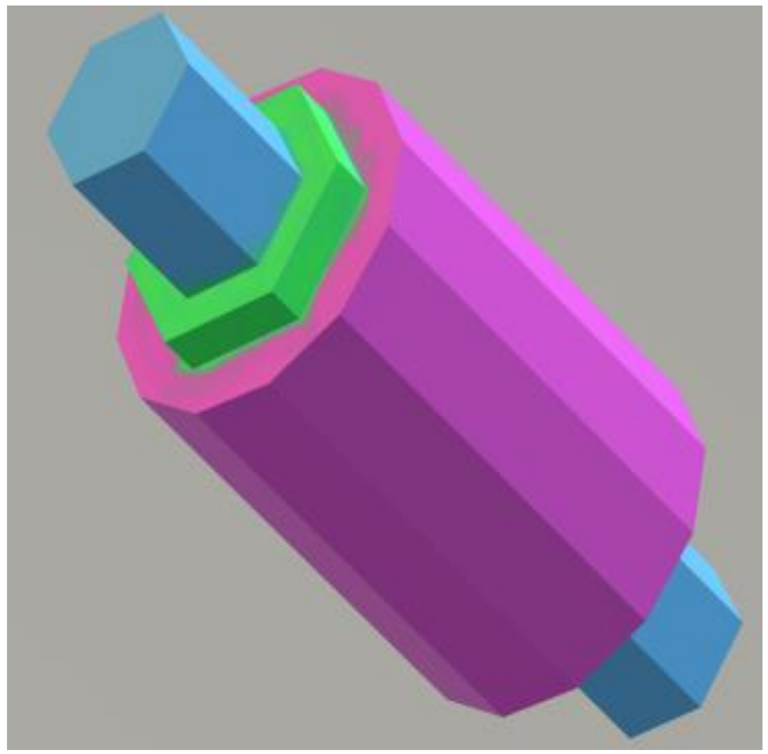


Selective area etching CDS Nanowire

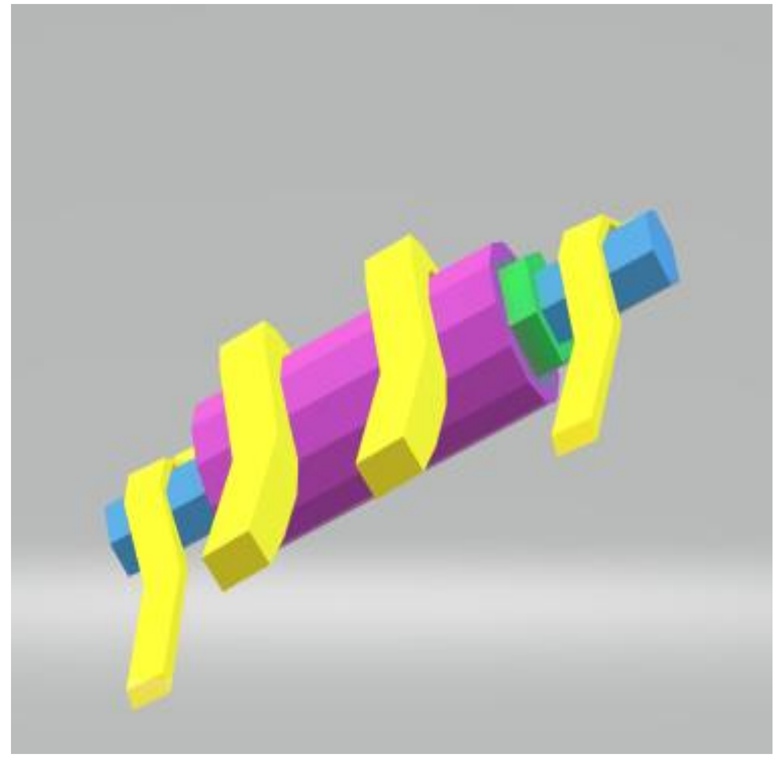
CDS NW



Etched CDS NW



Multiterminal device



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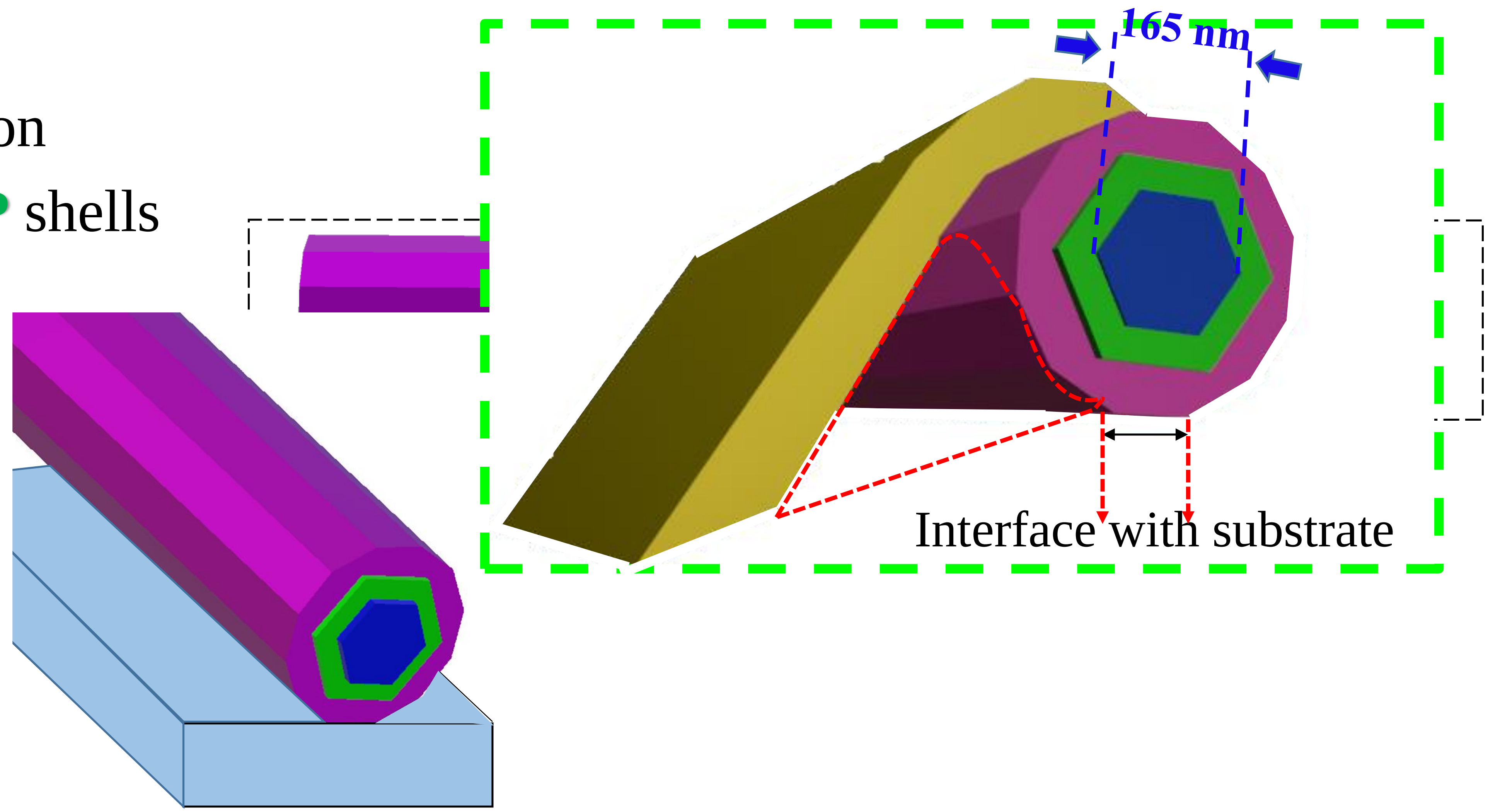
Etching process

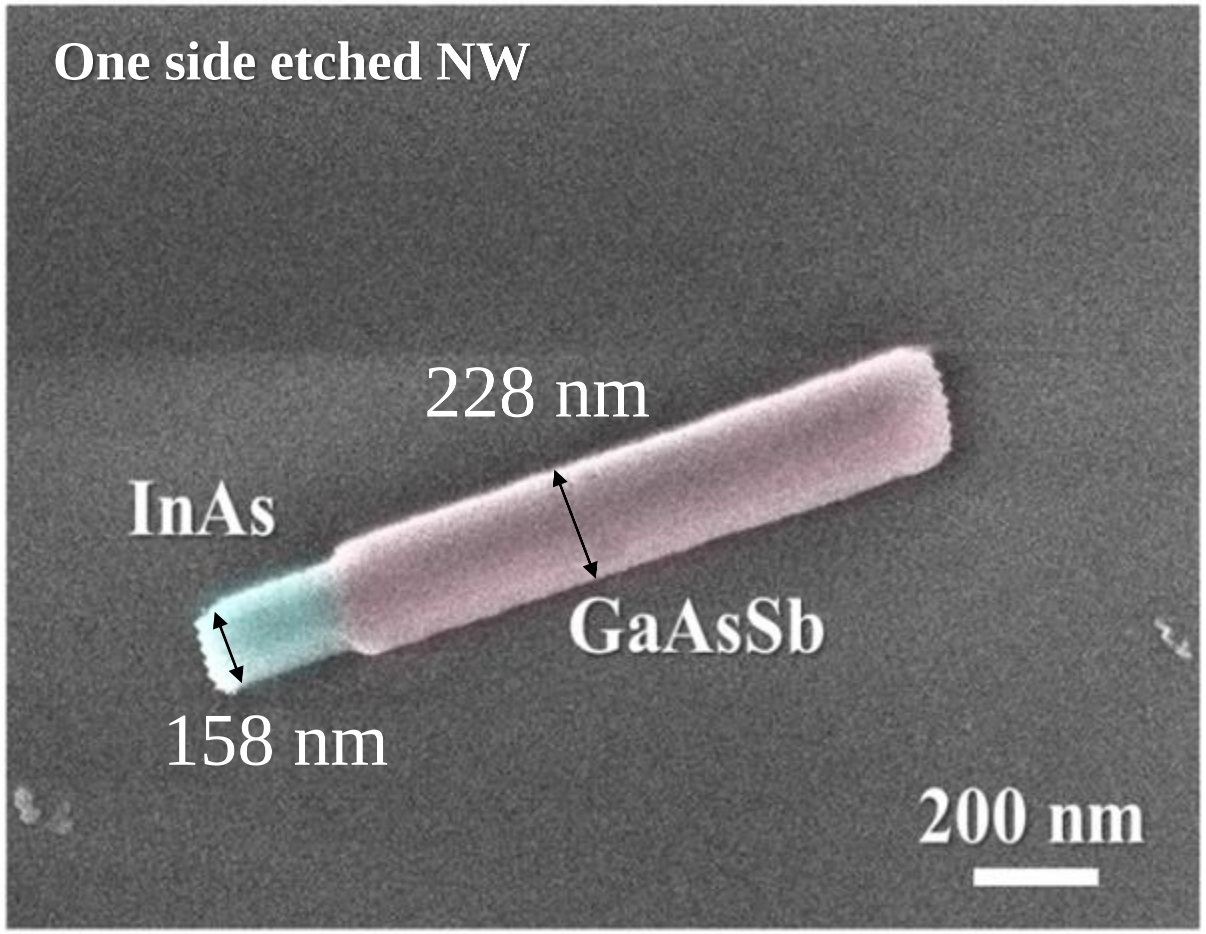
- Selective area etching from GaAsSb and InP

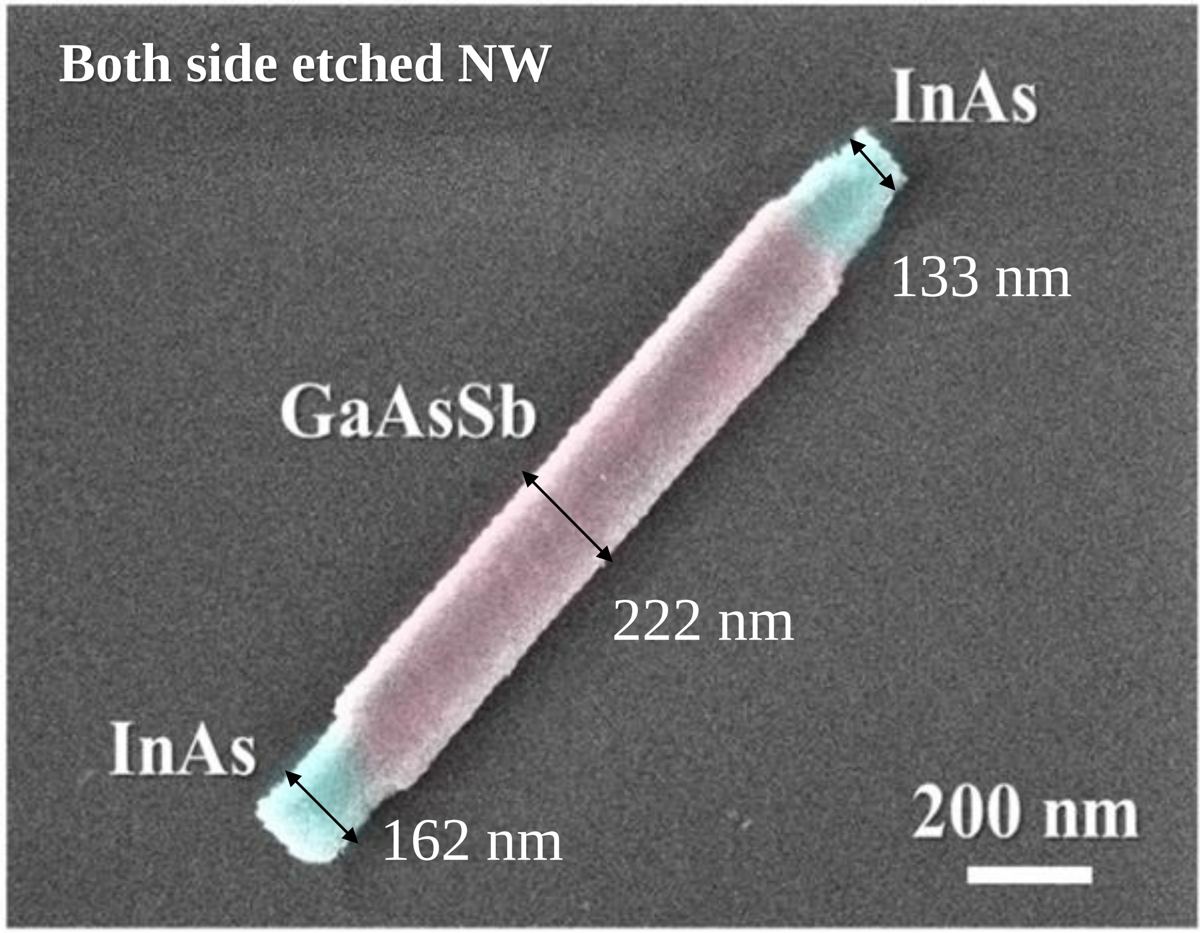
- Etchant calibration
  GaAsSb and **InP** shells

- NW geometry

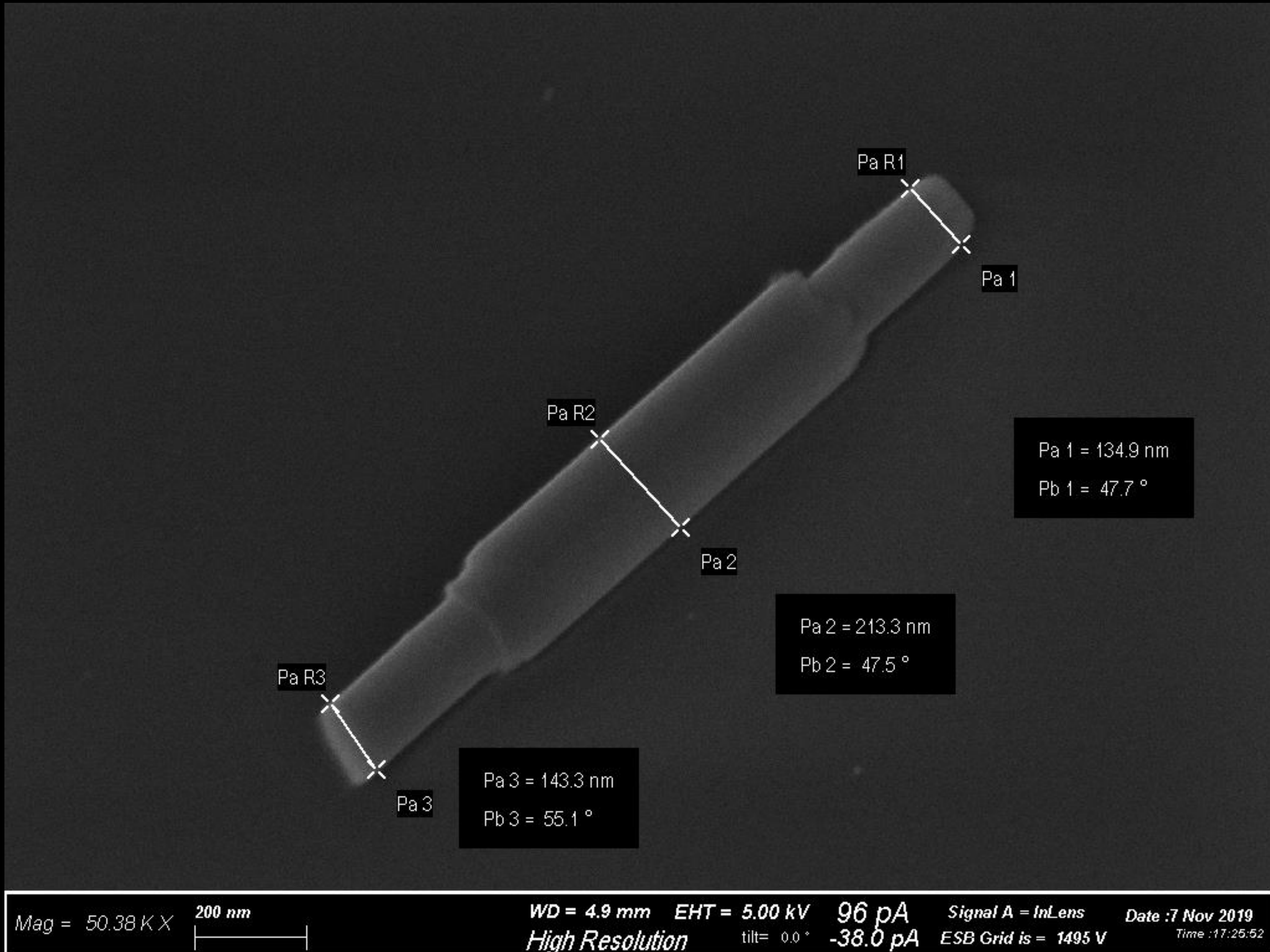


Selective area etching CDS Nanowire



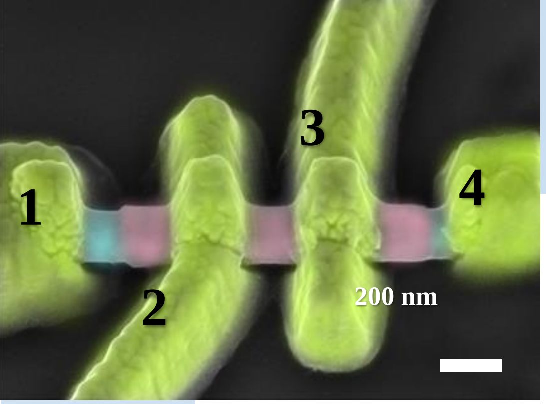


Selective area etching CDS Nanowire

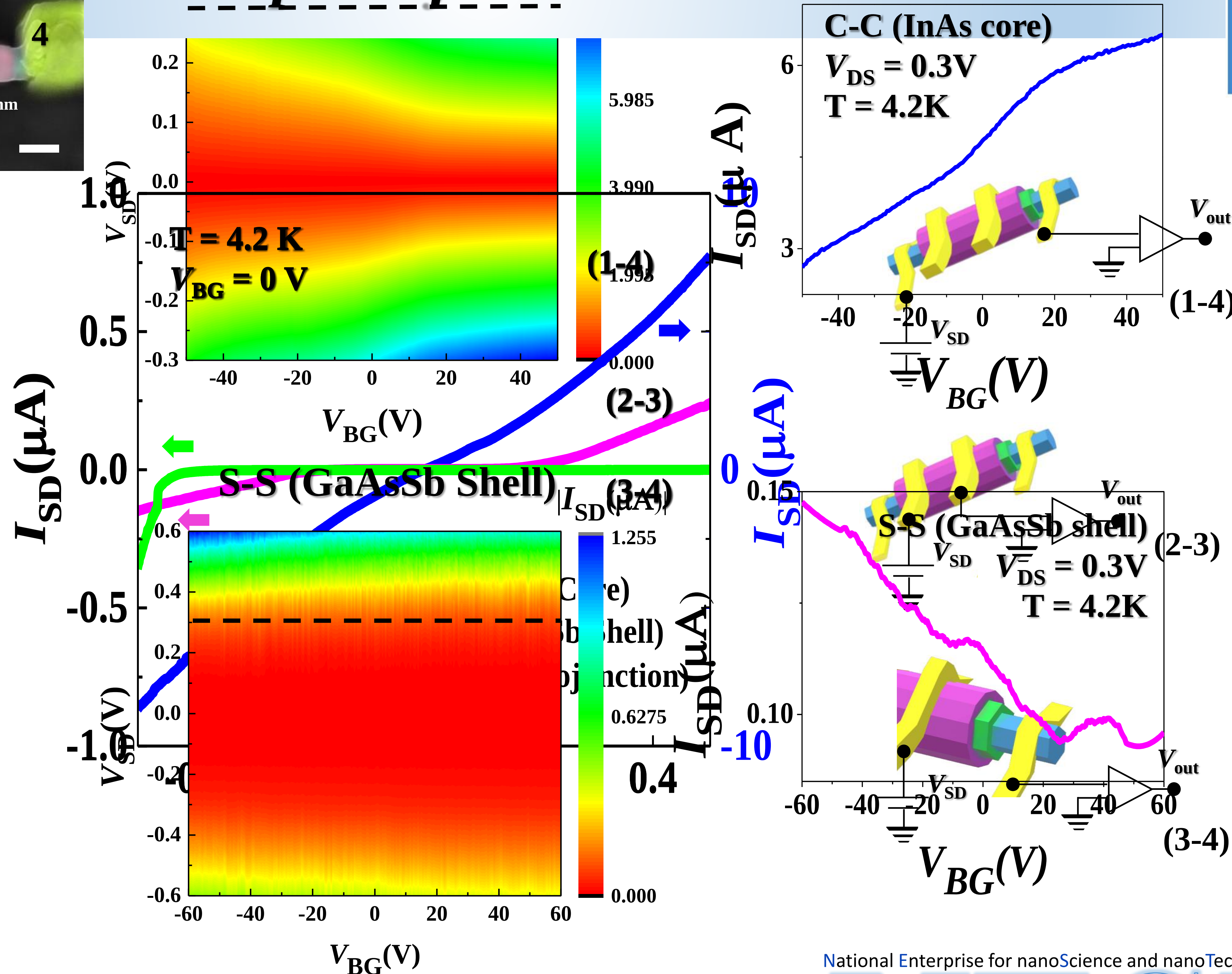


Multiterminal Core-Shell device

Impact of InP barrier



Separated channels charge carriers

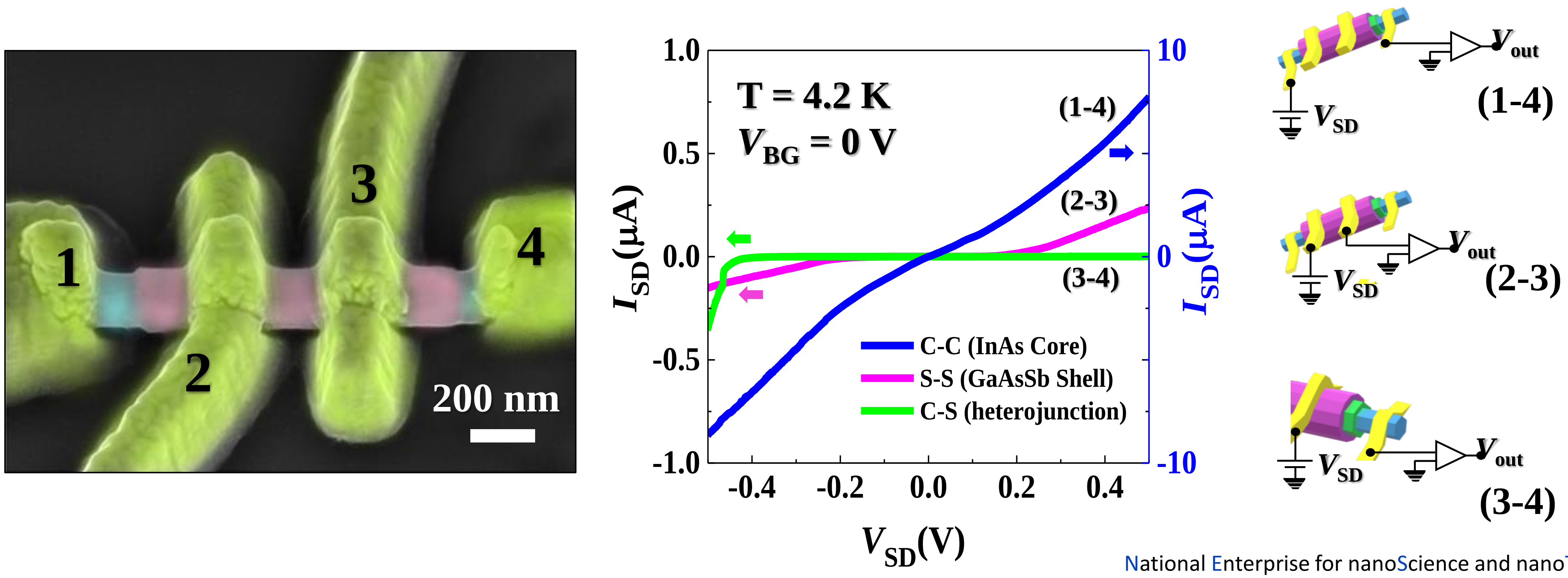


Nano Research 2020, 13(4): 1065–1070
ISSN 1998-0124 CN 11-5974/O4
https://doi.org/10.1007/s12274-020-2745-5

Research Article

Electrical probing of carrier separation in InAs/InP/GaAsSb core-dualshell nanowires

Sedighe Salimian[1] (✉), Omer Arif[1], Valentina Zannier[1], Daniele Ercolani[1], Francesca Rossi[2], Zahra Sadre Momtaz[1], Fabio Beltram[1], Sefano Roddaro[1,3], Francesco Rossella[1] (✉), and Lucia Sorba[1]



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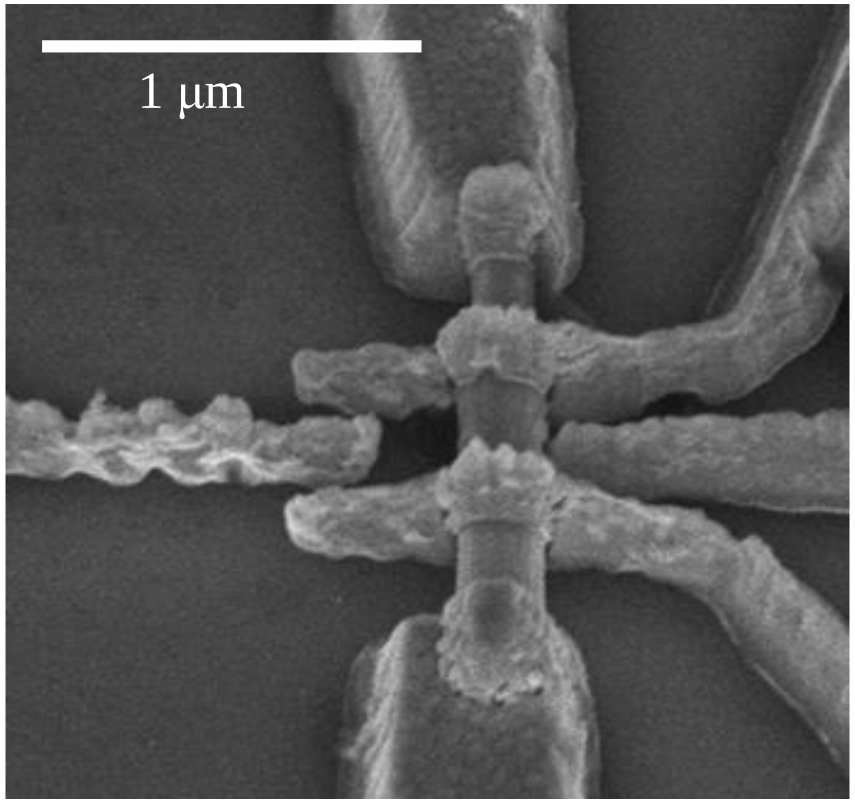
Where we are..



Graphene/unltrathin-Si_3N_4 heterostructure device

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- Why β-Si_3N_4

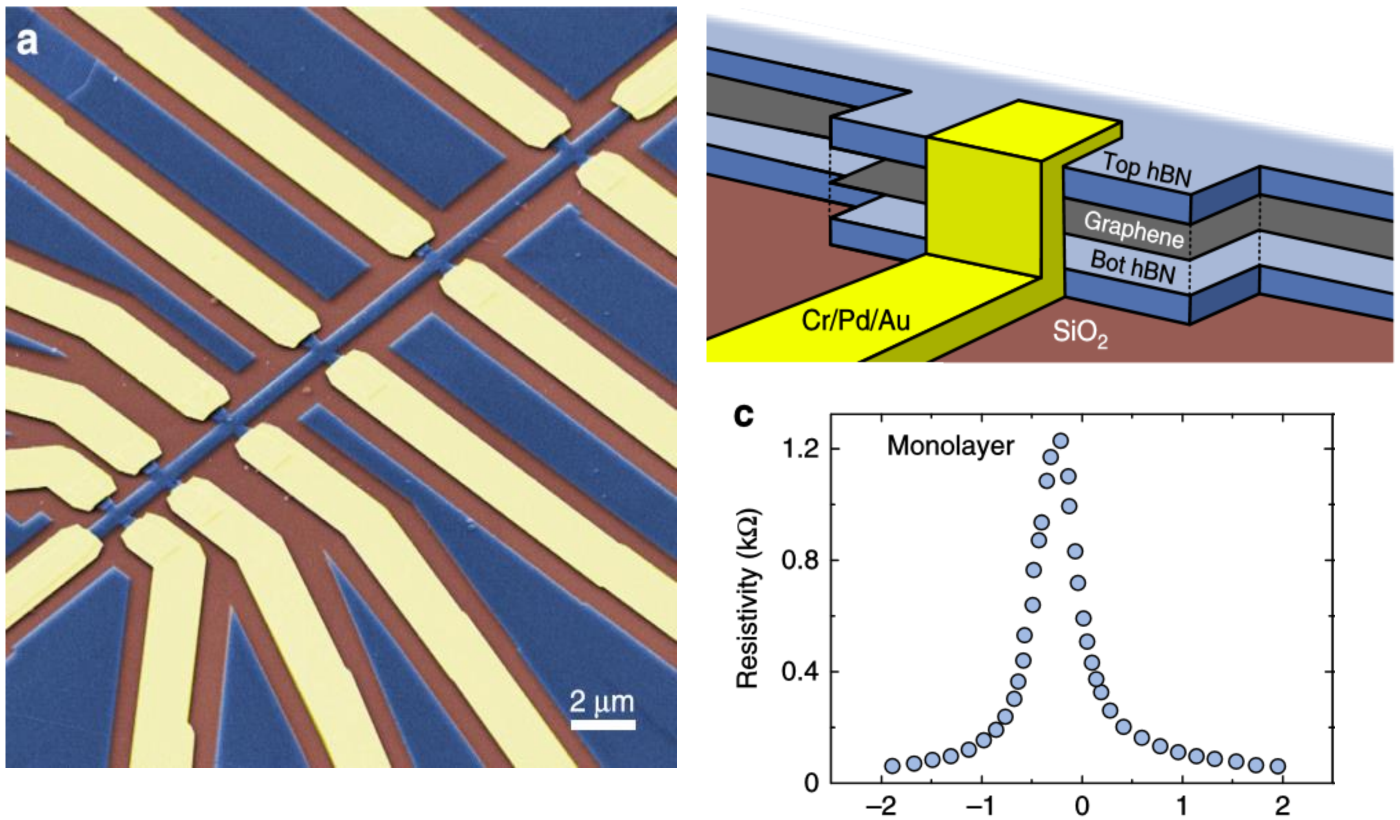
- Device structure

- STM on graphene/β–Si_3N_4 device

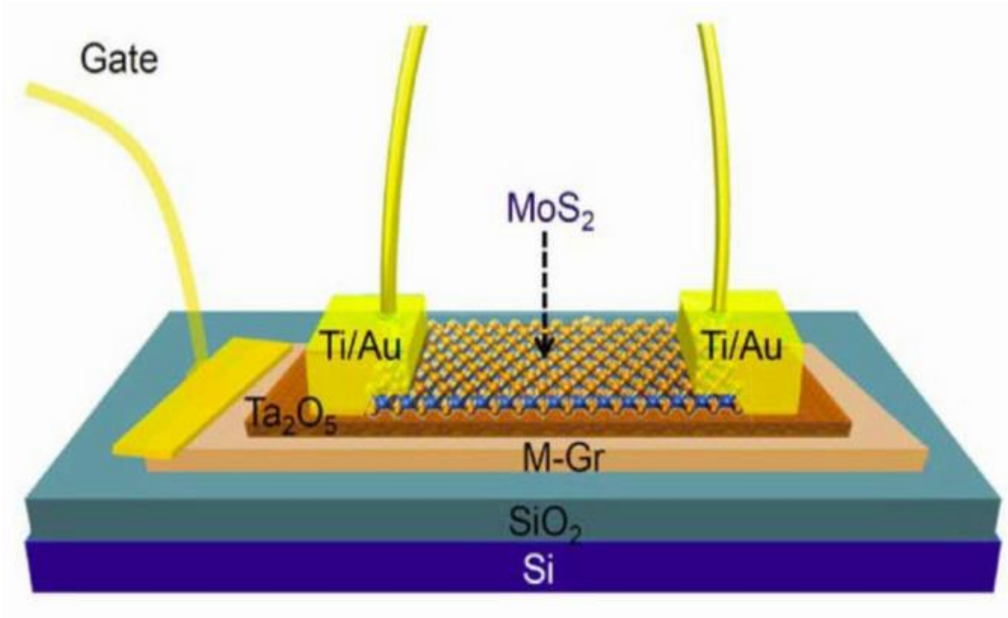
- Magneto-transport measurements

Why high-k Dielectric ?

- ✓Preserving the intrinsic mobility
- ✓Minimizing operation voltage



F. Pizzocchero etal. Nature Com. (2016)



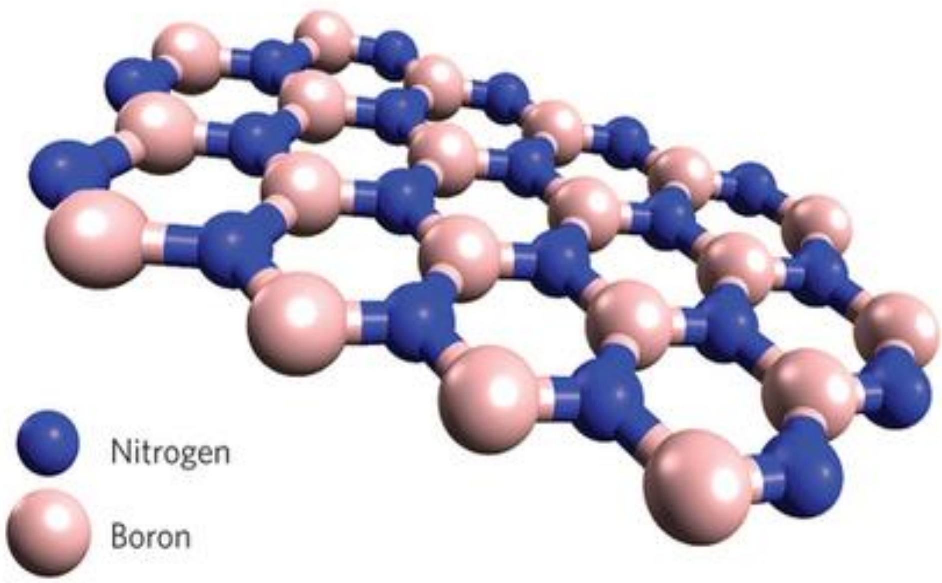
B. Chamlagain etal. 2D Mater. (2017)

Si_3N_4 Potential

Lattice mismatch (G/Si_3N_4)= 3.66 %
Ɛ = 6.6
Eg= 5.3 eV

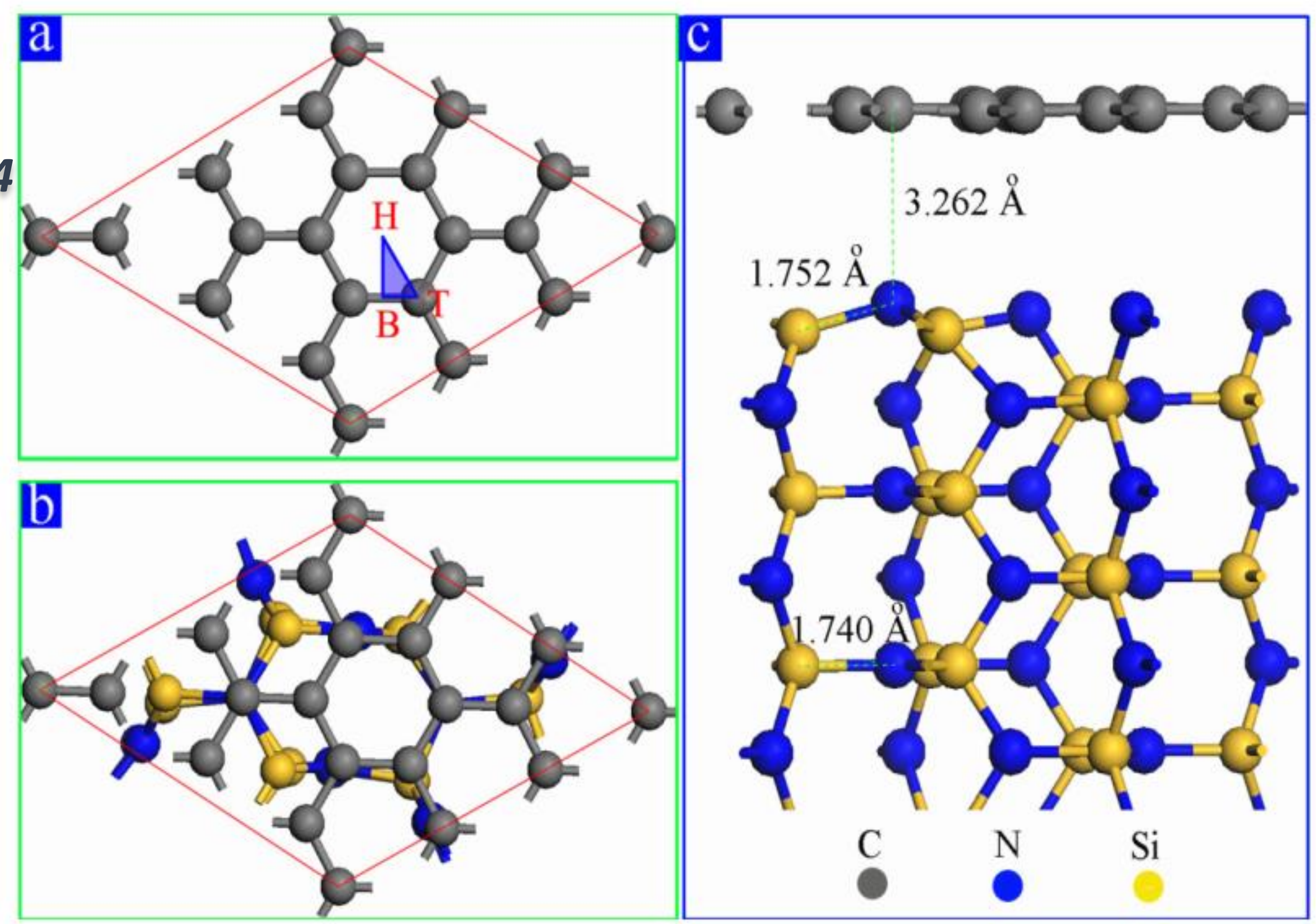
Lattice mismatch (G/hBN)= 1.8 %
Ɛ = 3 - 4
Eg= 6 eV

hBN



Ttrong etal. Nature Nanotech. **(2016)**

Si_3N_4



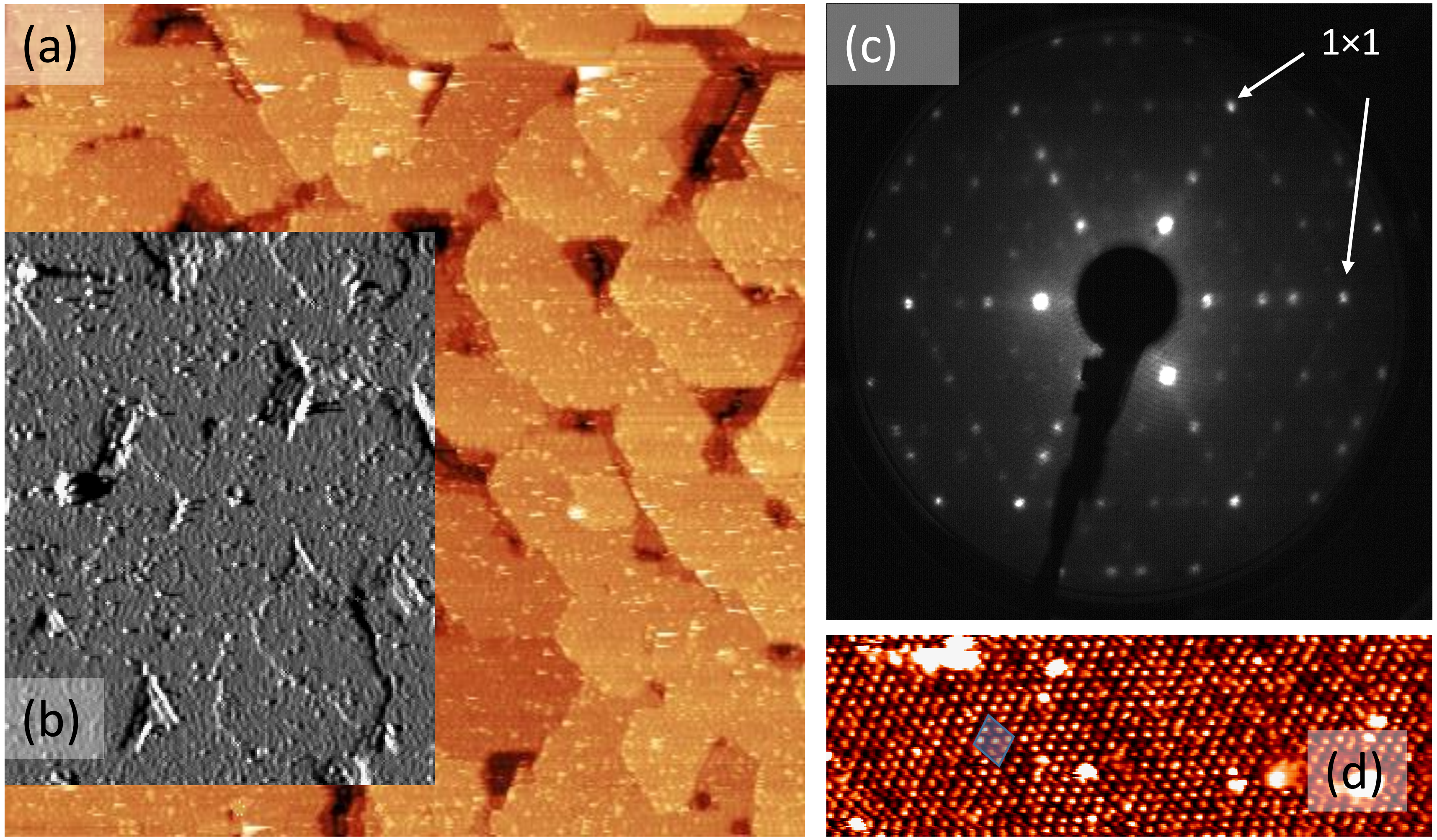
Yang etal. AIP Advances (2011)

The β-Si_3N_4(0001)/Si(111) substrate; STM, LEED

500×500 nm^2

LEED pattern → (8×8) reconstruction

derivative along the x-direction



50×16 nm^2

Less than 1nm thick large area crystalline ***β-Si_3N_4***

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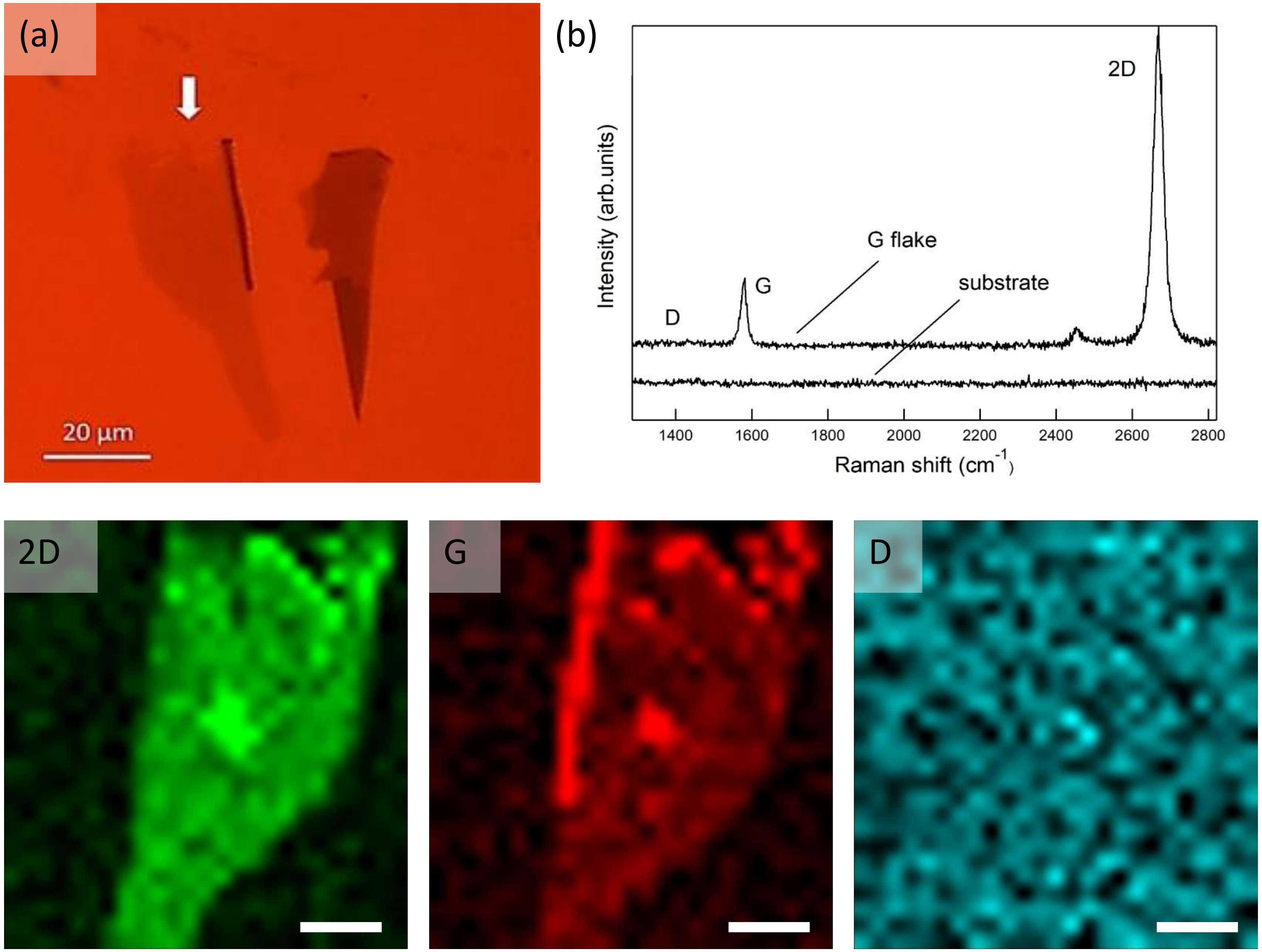
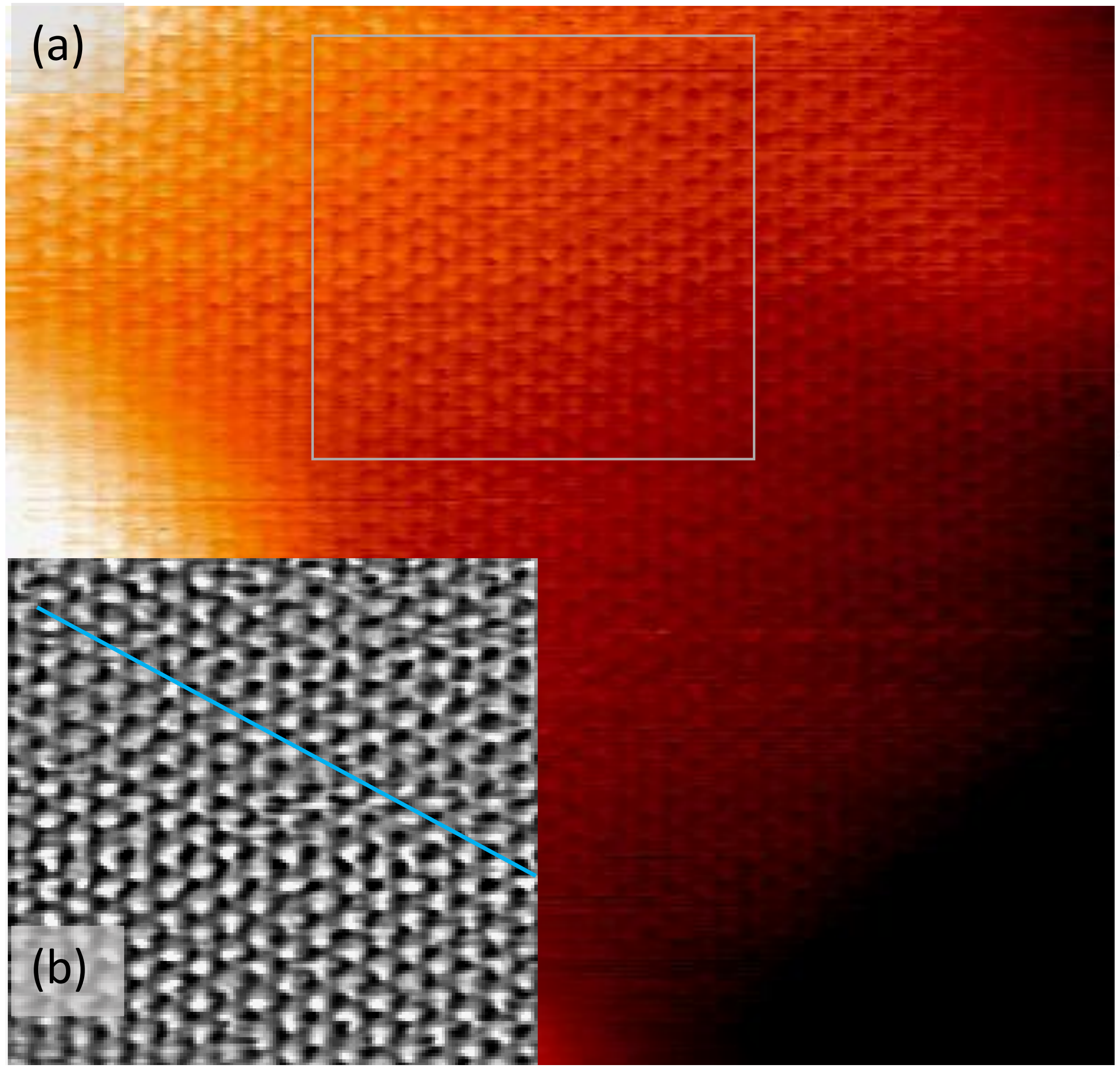
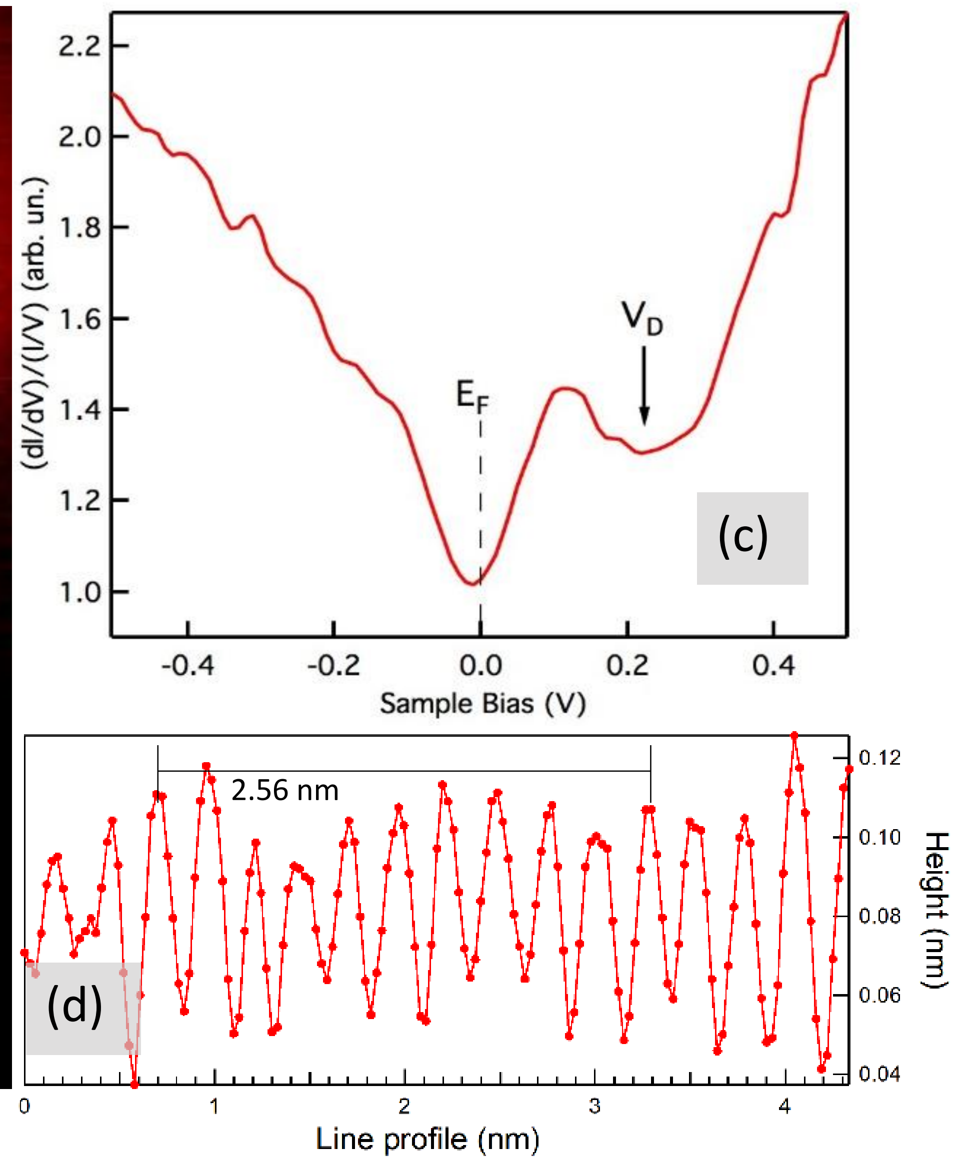
Graphene on β–Si_3N_4(0001)/Si(111)

Graphene on β–Si_3N_4(0001)/Si(111); Raman Spectroscopy



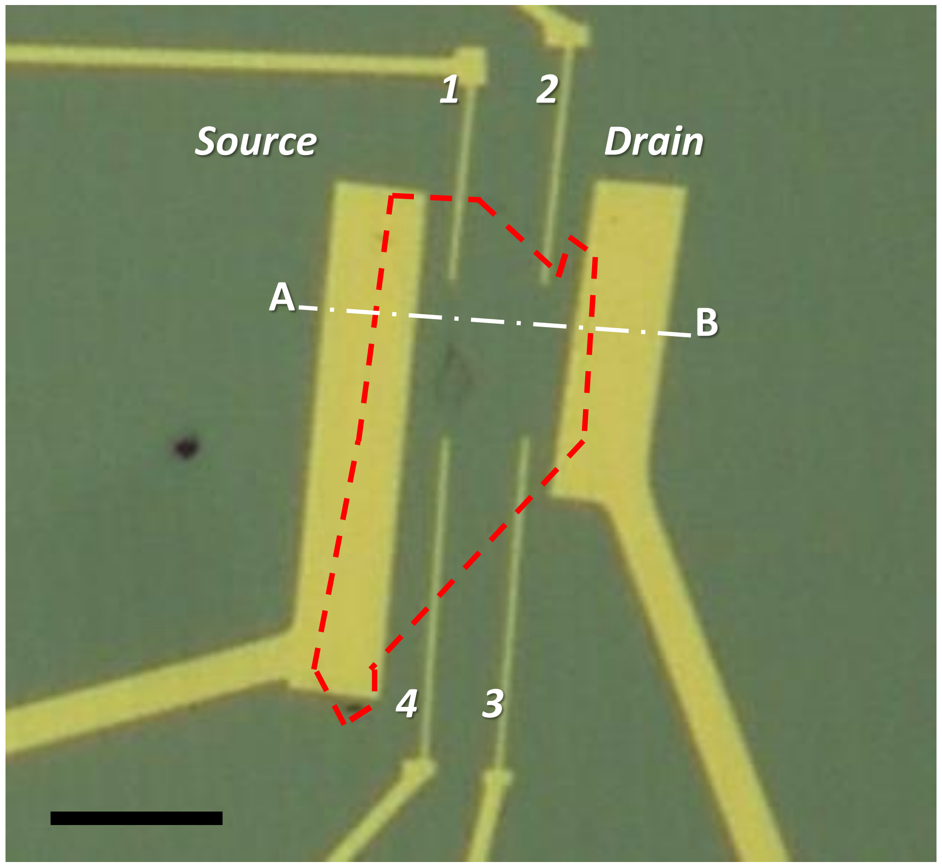
Graphene on β–$Si_3N_4(0001)/Si(111)$: STM, STS

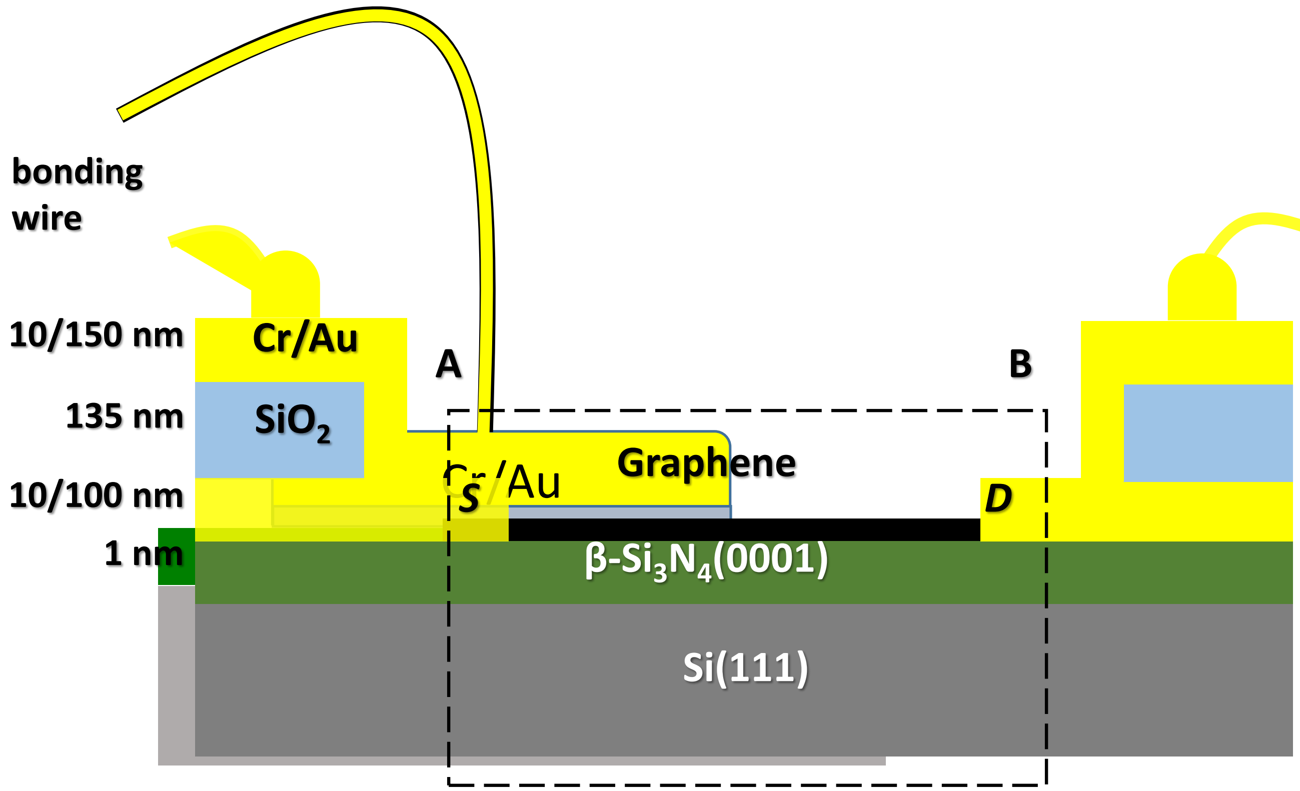




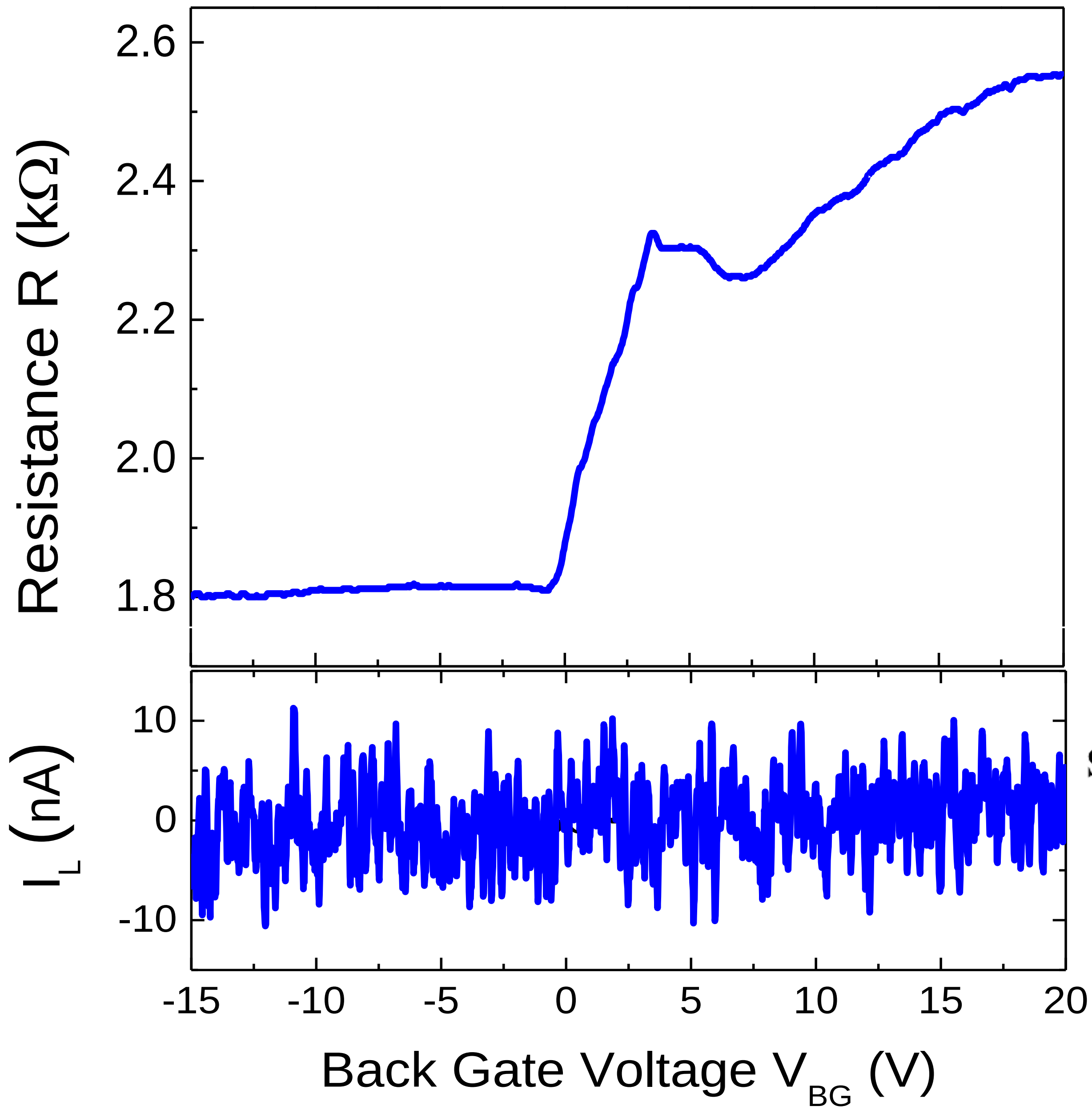
Magnetotransport measurement

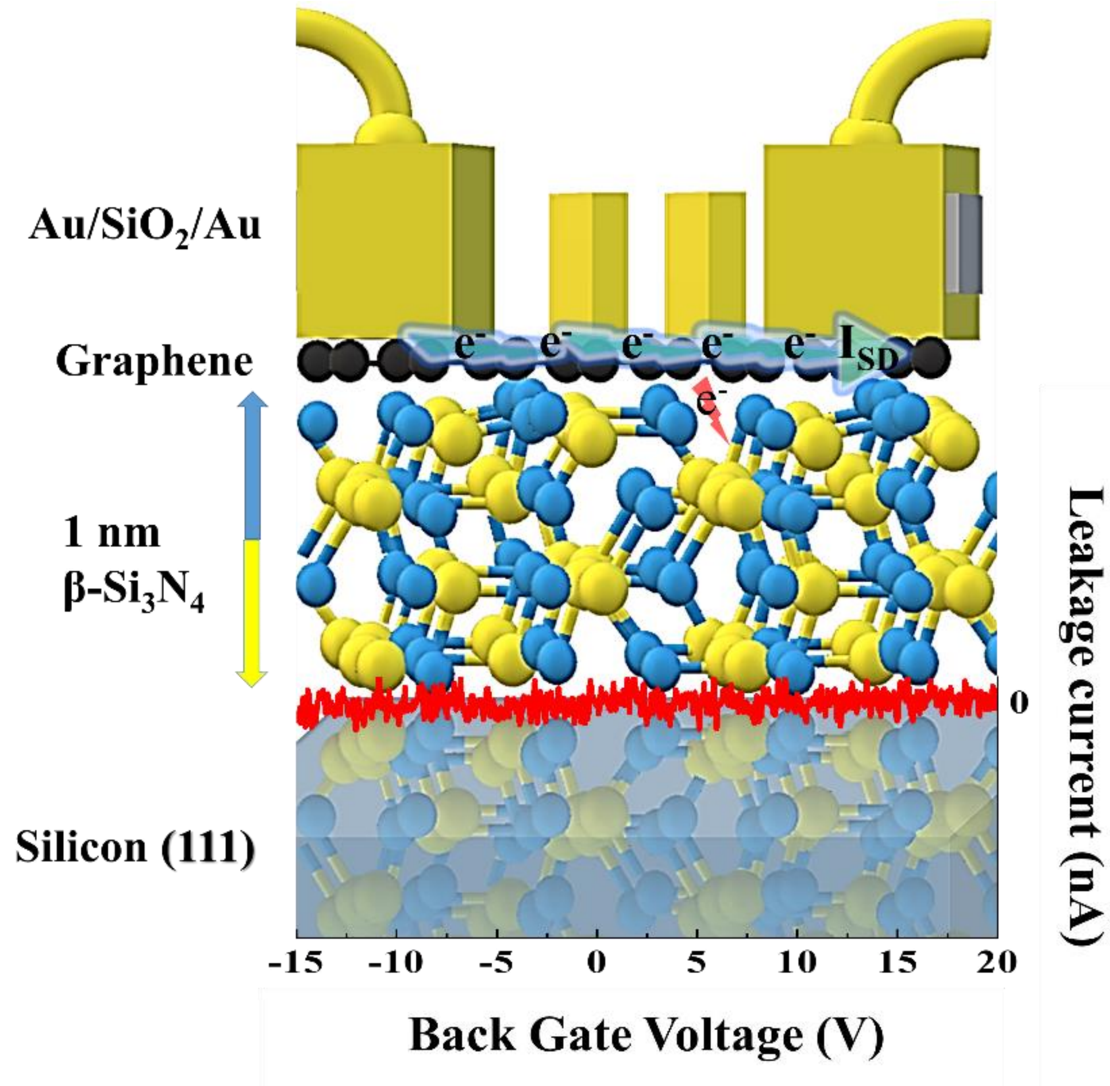
Device structure



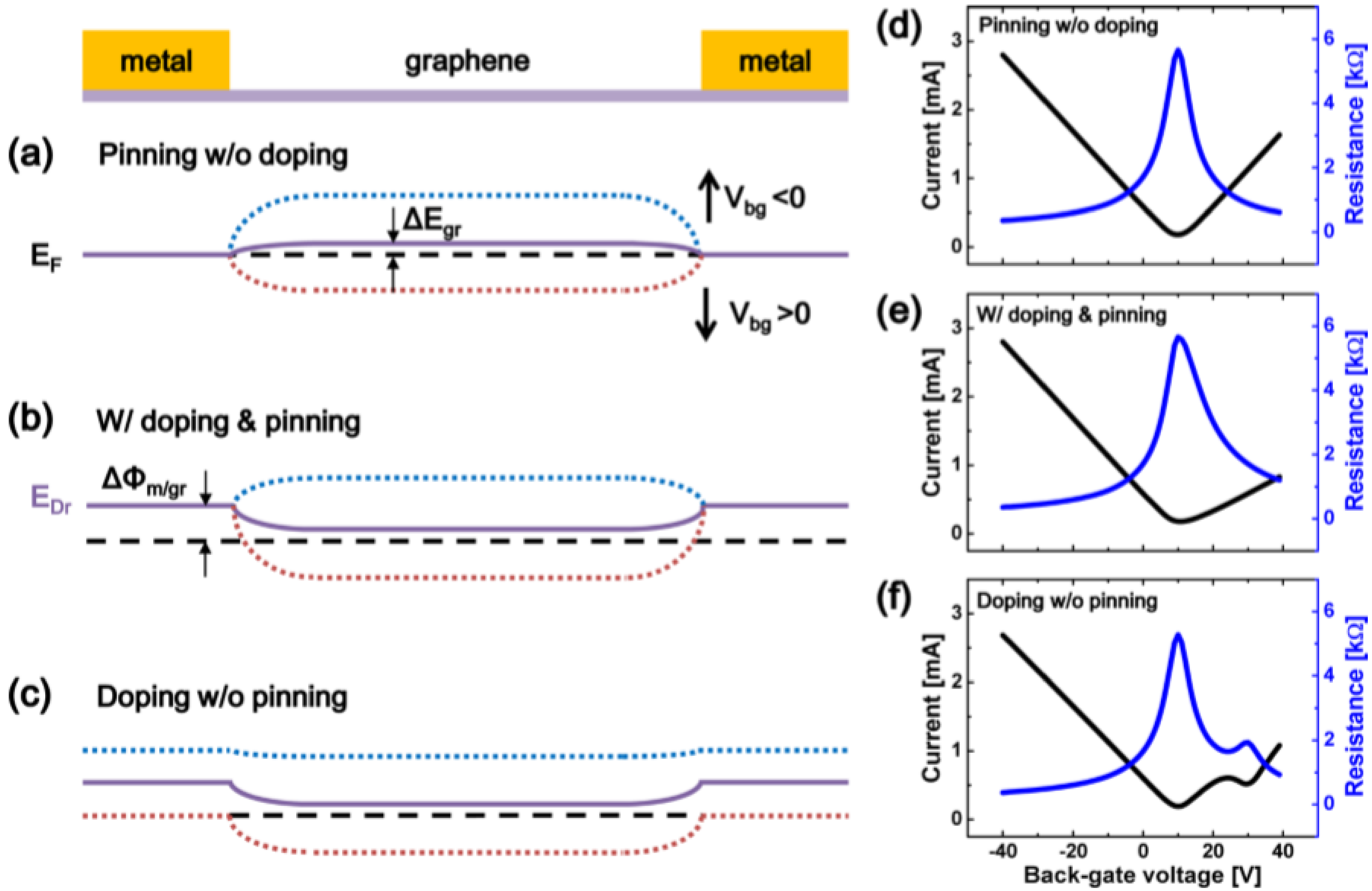


Electrical transport at 4.2 K





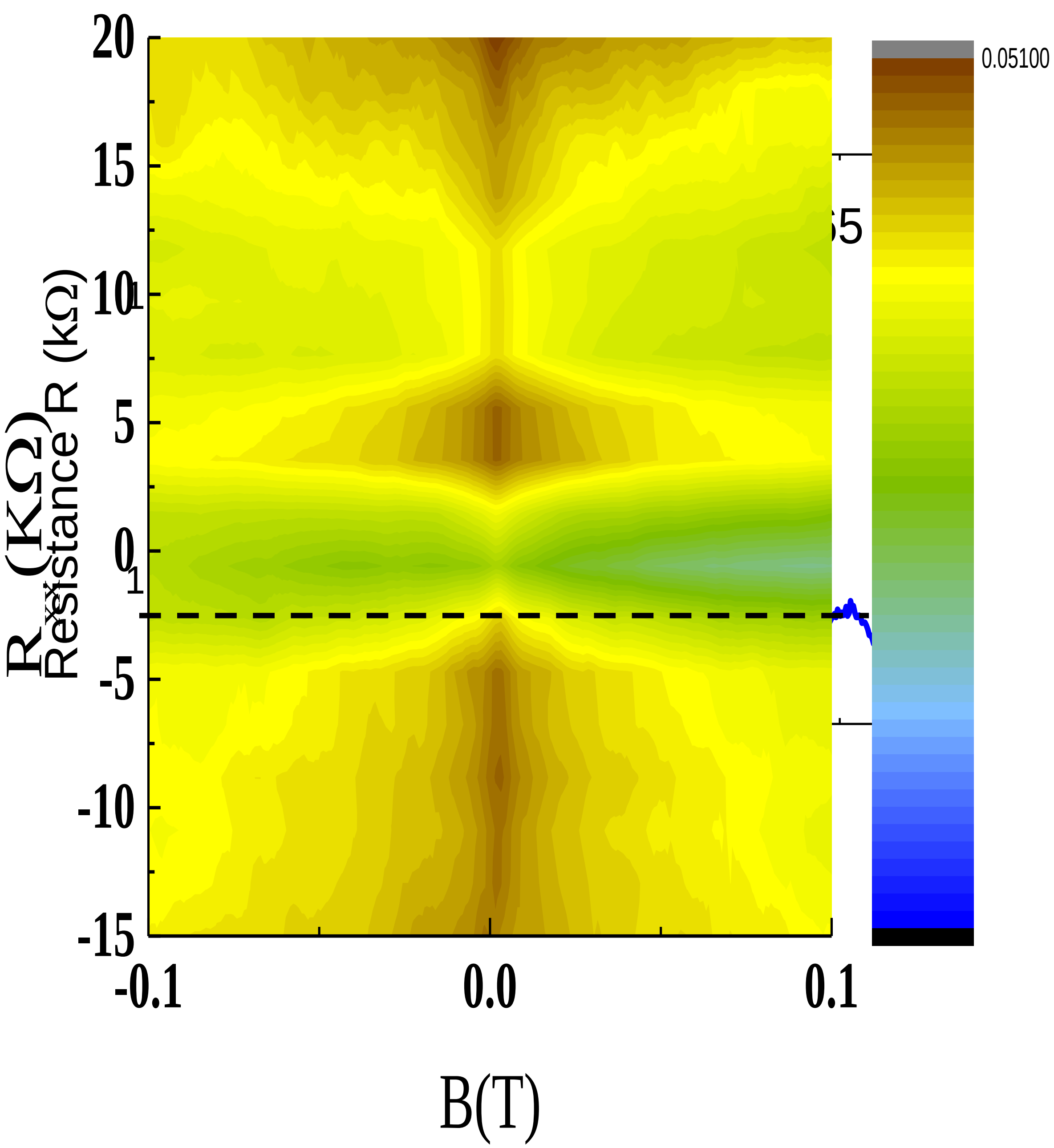
The Origin of second Dirac Point...

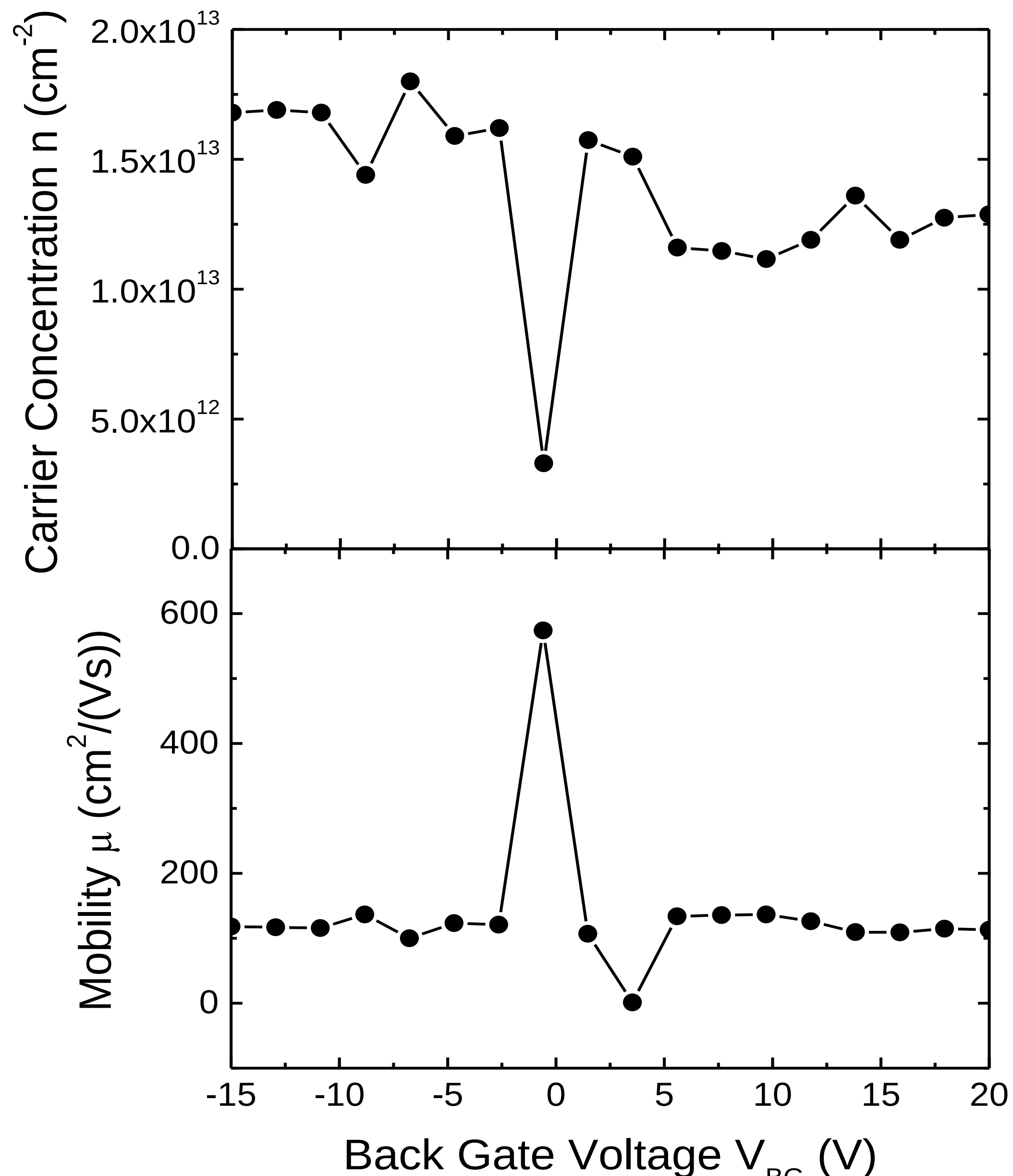


S.M. Song etal. Carbon Let. (2013)

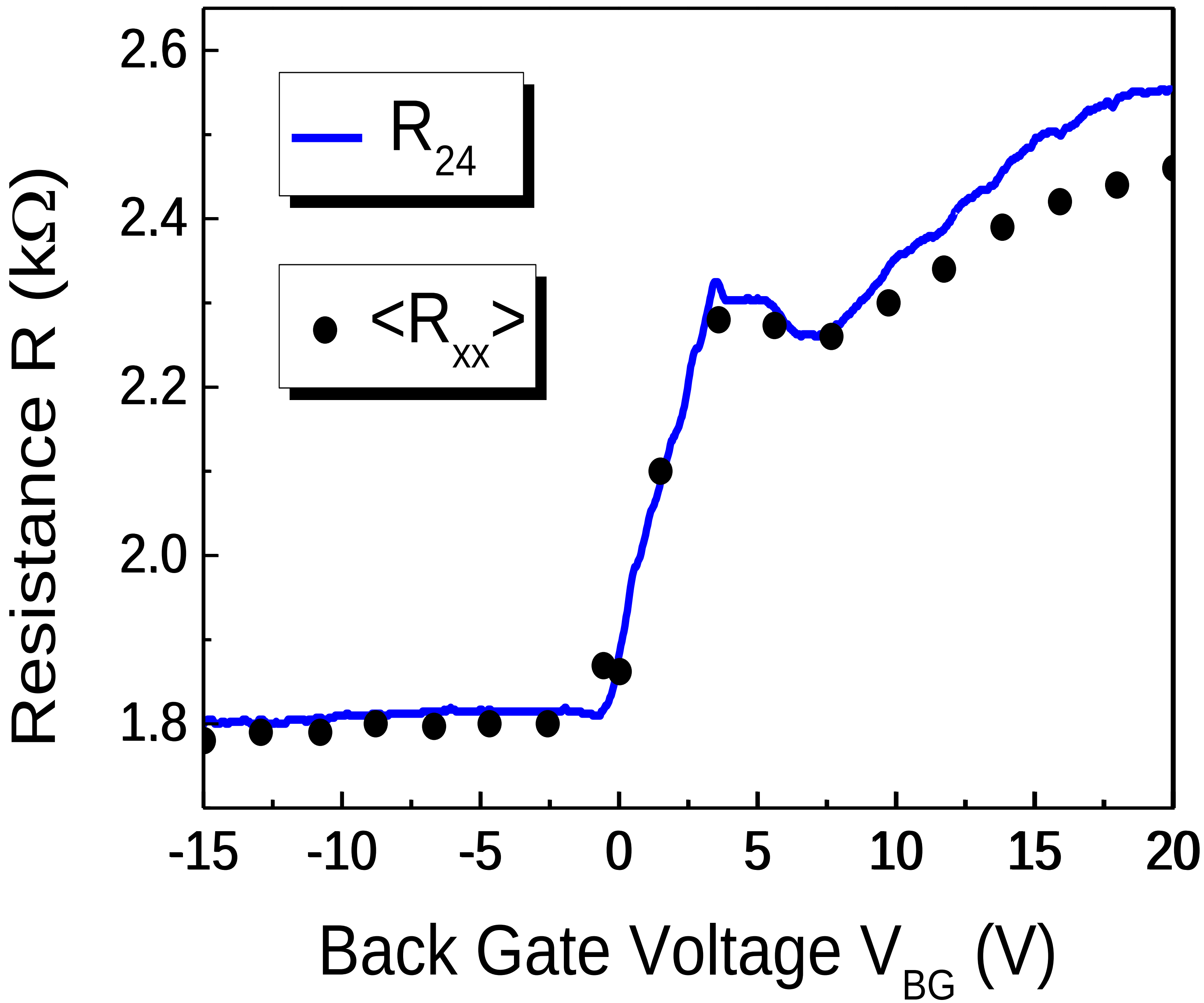
Magnetotransport measurement

$$\frac{R(B) - \langle R \rangle_B}{\langle R \rangle_B}$$

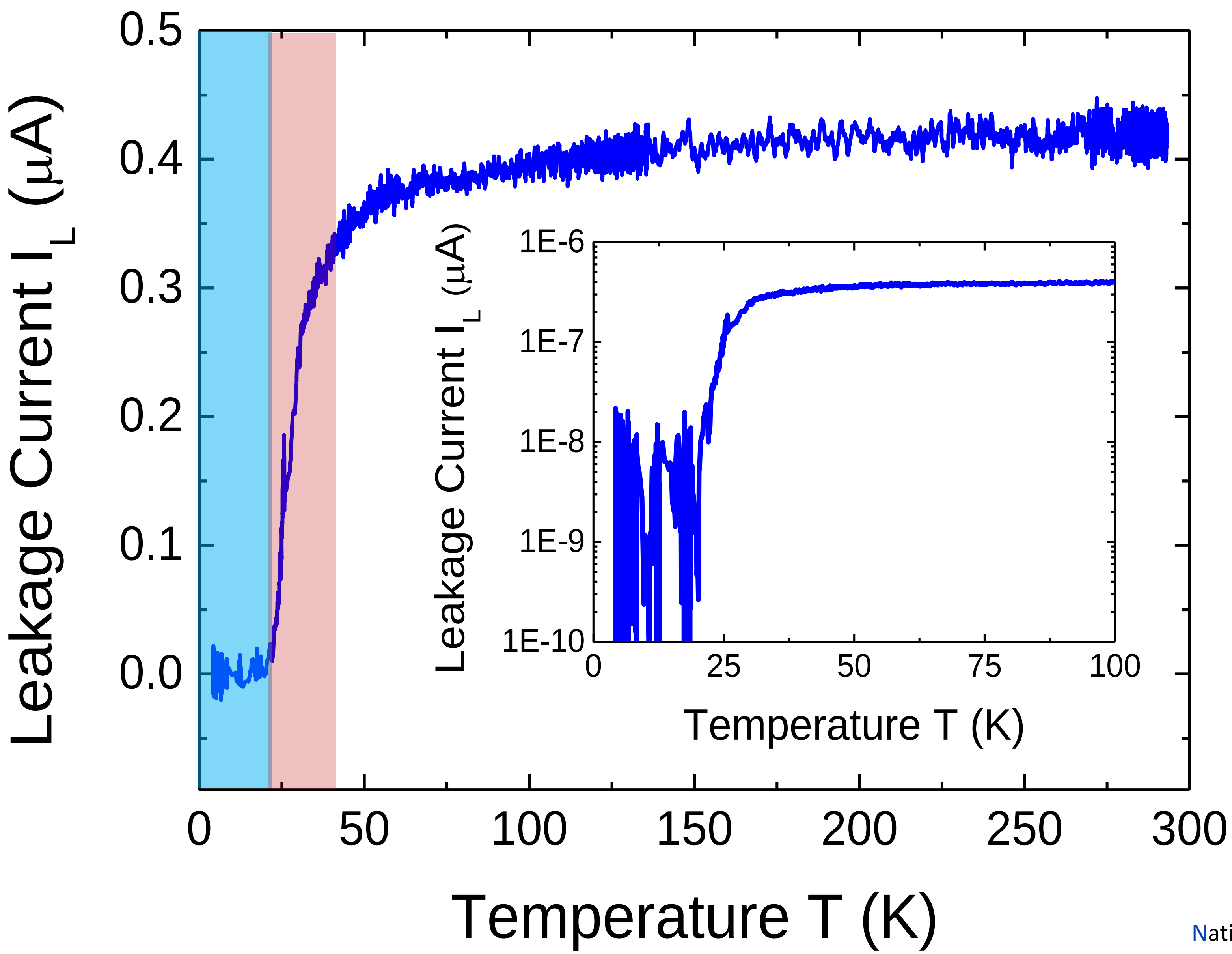


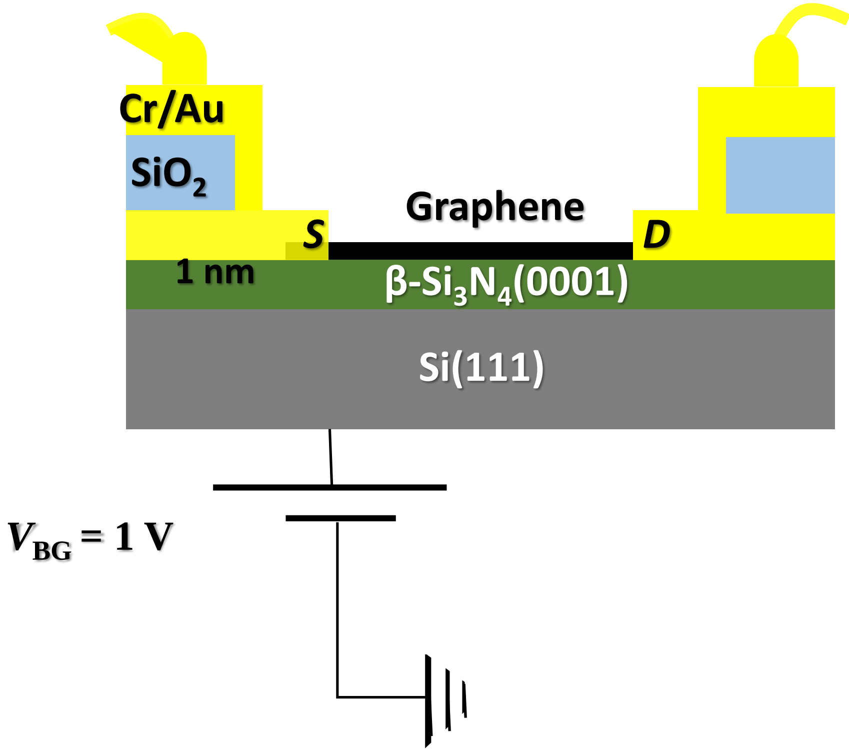


Field Effect and Hall Effect



Temperature dependence leakage current





In a Nutshell

- ***Large*** area grown ***Crystaline*** β-Si_3N_4(0001)
- Observation of ***charge carrier modulation***
- ***Very low leakage current at 4.2 K*** in this ultrathin high-k Dielectric

Temperature dependence leakage current

FULL PAPER

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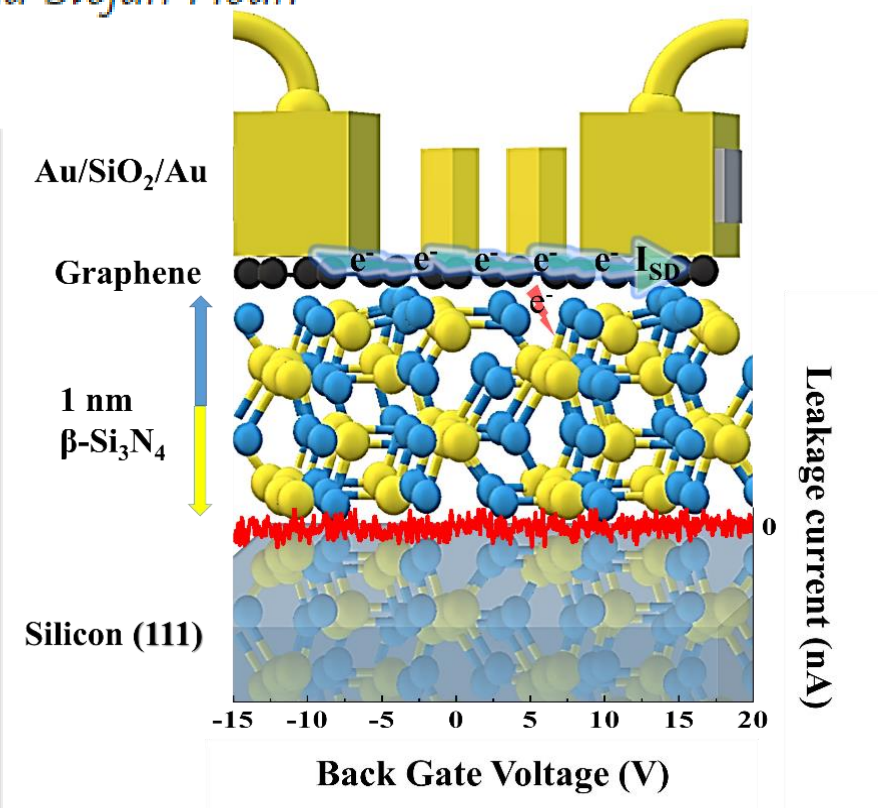
Morphology and Magneto-Transport in Exfoliated Graphene on Ultrathin Crystalline β-$Si_3N_4(0001)/Si(111)$

Sedighe Salimian, Shaohua Xiang, Stefano Colonna, Fabio Ronci, Marco Fosca, Francesco Rossella, Fabio Beltram, Roberto Flammini, and Stefan Heun**

This work reports the first experimental study of graphene transferred on β-$Si_3N_4(0001)/Si(111)$. A comprehensive quantitative understanding of the physics of ultrathin Si_3N_4 as a gate dielectric for graphene-based devices is provided. The Si_3N_4 film is grown on Si(111) under ultra-high vacuum (UHV) conditions and investigated by scanning tunneling microscopy (STM). Subsequently, a graphene flake is deposited on top of it by a polymer-based transfer technique, and a Hall bar device is fabricated from the graphene flake. STM is employed again to study the graphene flake under UHV conditions after device fabrication and shows that the surface quality is preserved. Electrical transport measurements, carried out at low temperature in magnetic field, reveal back gate modulation of carrier density in the graphene channel and show the occurrence of weak localization. Under these experimental conditions, no leakage current between back gate and graphene channel is detected.



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Stefano Colonna

Roberto Flammini

Shaohua Xiang

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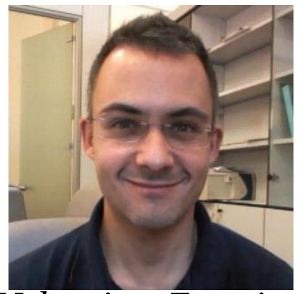
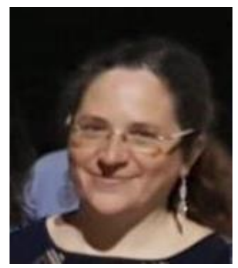
Francesco Rosella

Daniele Ercolani



Valentina Zannier

Stefano Rodaro



Francesca Rossi

Ang Li

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