Quantum transport in asymmetric graphene structures

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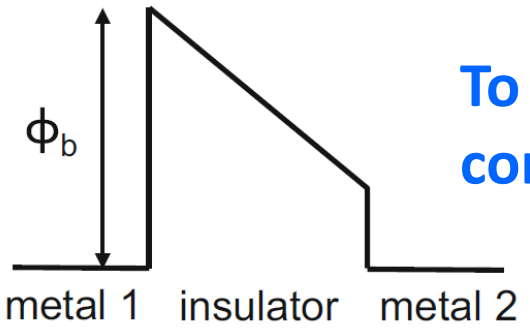
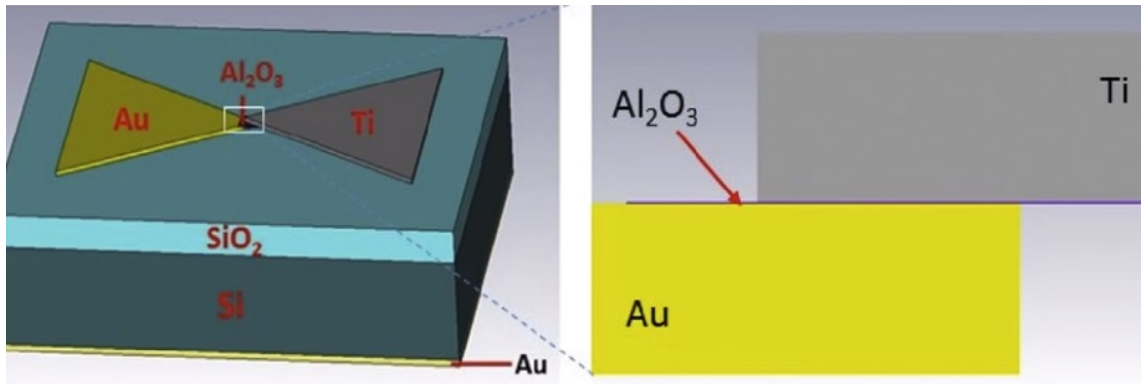
GreEnergy

High frequency rectification

MIM diode (metal-insulator-metal)

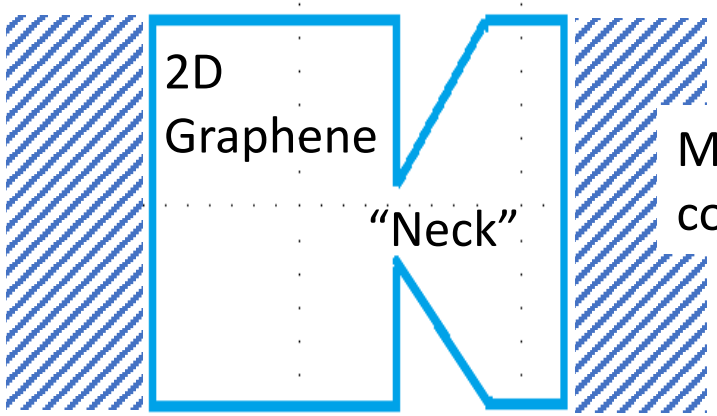


To avoid large time constants (RC product)

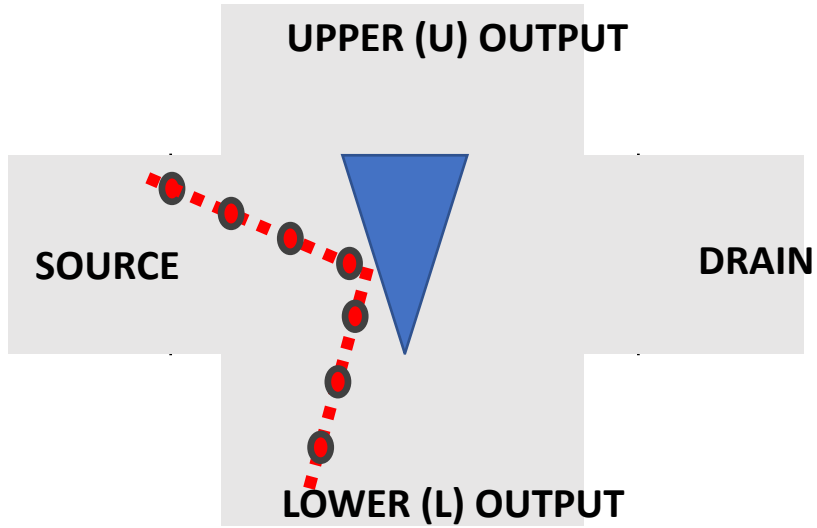


Graphene based geometric diodes

2 Port Device



4 Port Device



The modelling of coherent charge transport is carried out by Scattering Matrix (SM) formulation, under the following assumptions:

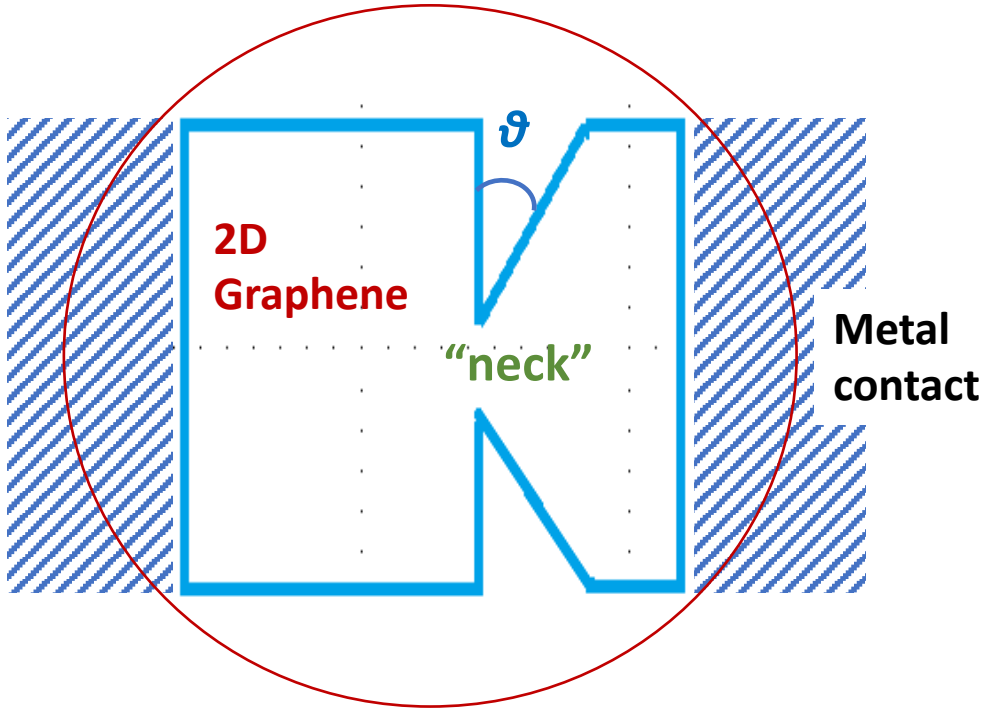
- low metal-contact resistance
- ballistic transport

Parameter sensitivity

For the 2 port device the numerical simulation provides the dependence of the I-V curve on:

2 Port Device

- the angle of the graphene taper
- the neck size

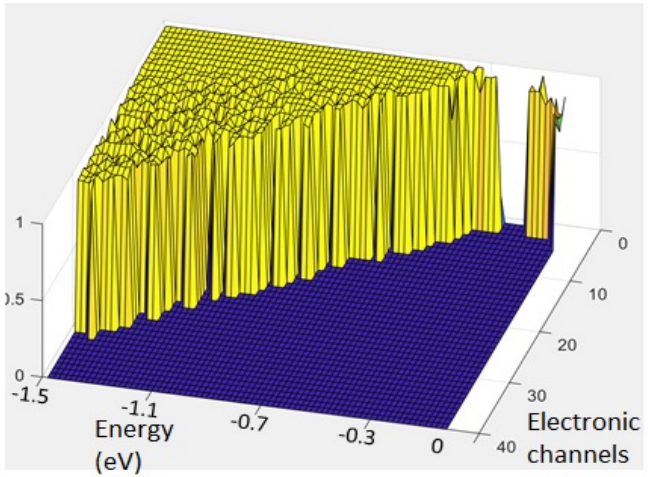


The final goal of the modelling is to find an optimum configuration of the above parameters, in terms of:

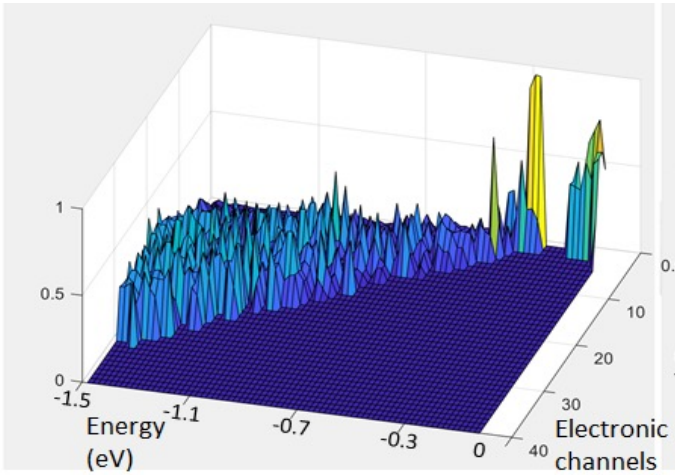
- asymmetry of the current voltage characteristic
- diode resistance
- reverse-bias leackage current

SM calculation example [20 x 20 nm^2 diode, 4 nm neck, 1.5 V]

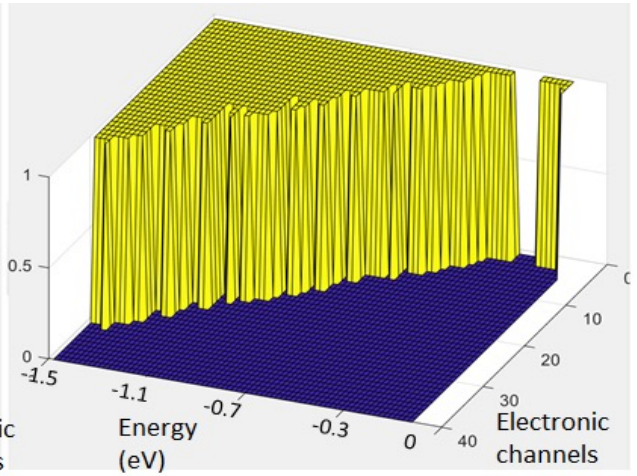
Charge reflection R



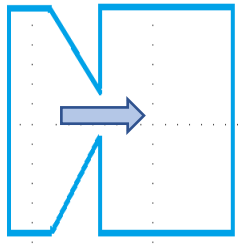
Charge transmission T

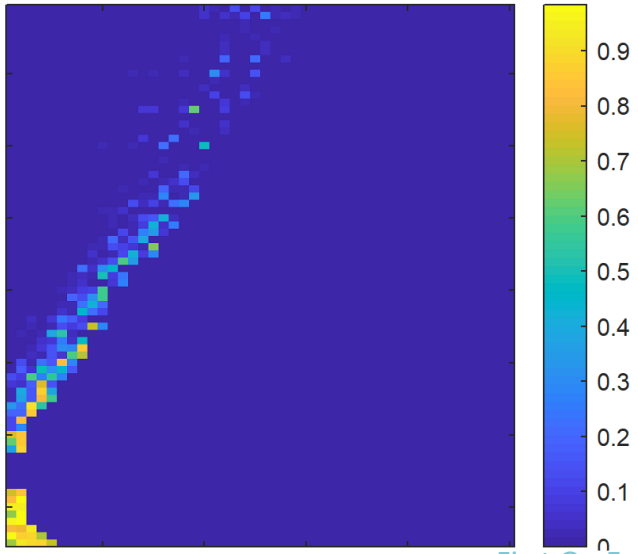


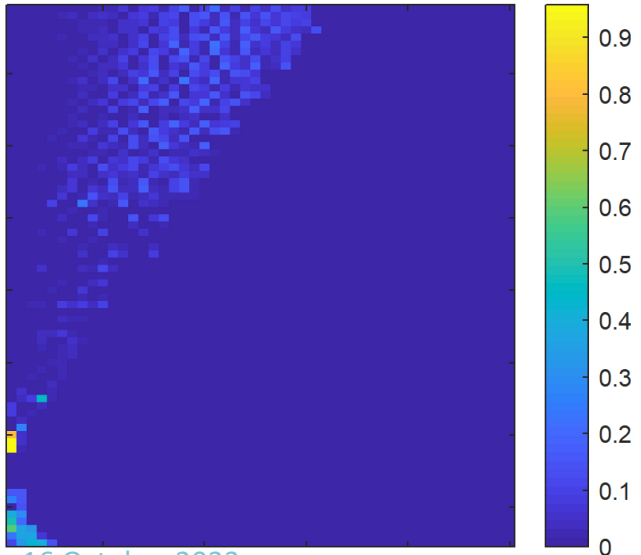
T+R (=1, numerical consistency)



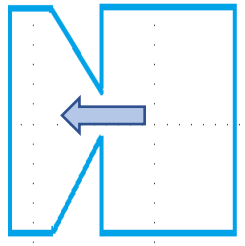
Left transmission



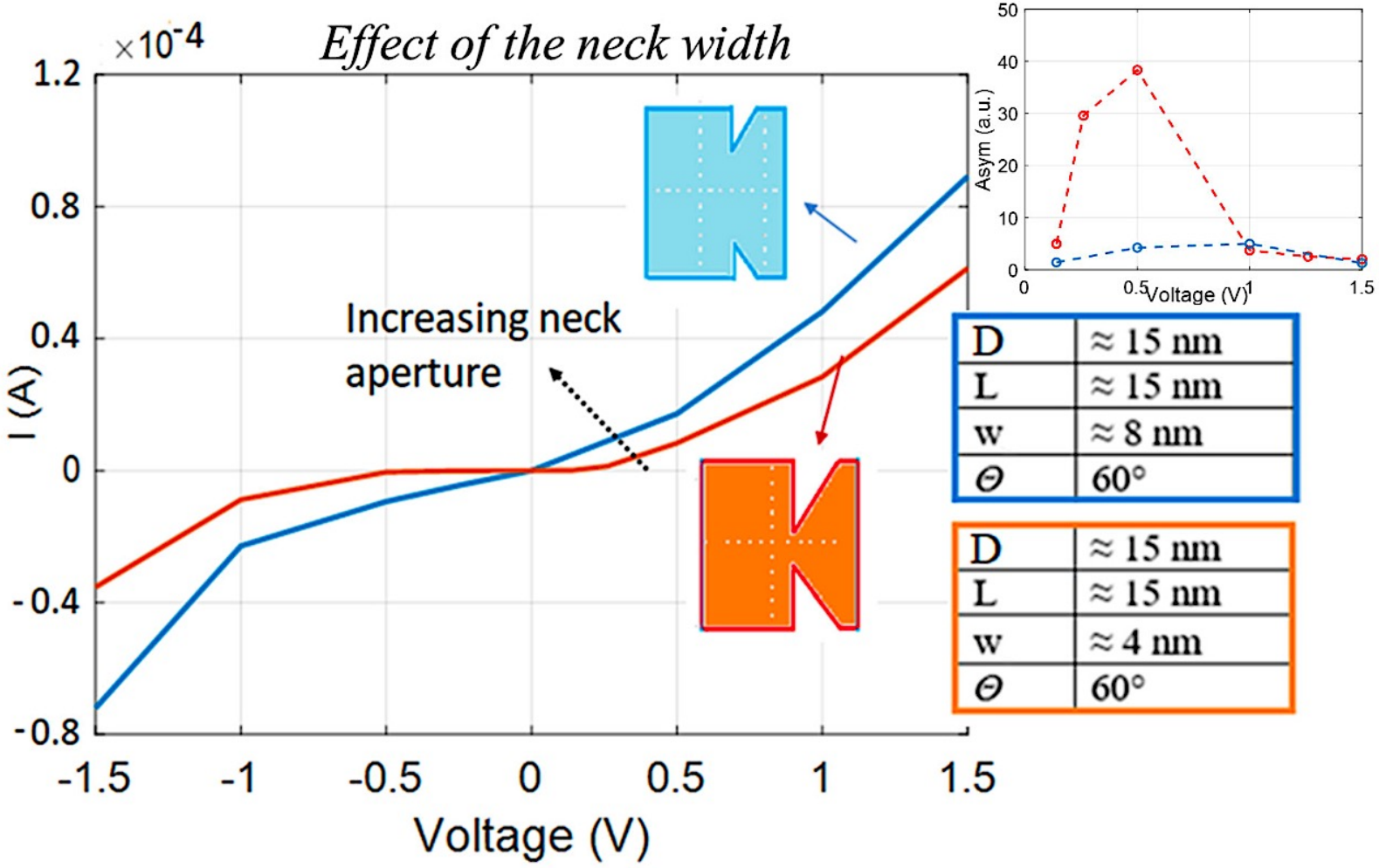




Right transmission

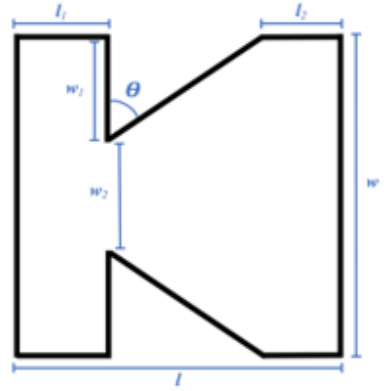


Effect of the **neck size**



D	≈ 15 nm
L	≈ 15 nm
w	≈ 8 nm
Θ	60°

D	≈ 15 nm
L	≈ 15 nm
w	≈ 4 nm
Θ	60°



To isolate the neck effect transparent metal contacts are assumed

Decreasing the neck size:
a. the I-V asymmetry increases
b. the amount of current reduces (diode impedance increases)
c. the reverse-bias current reduces

Effect of the **neck angle**

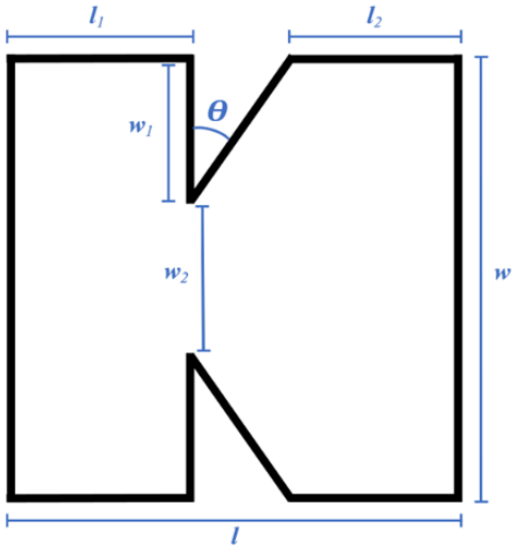
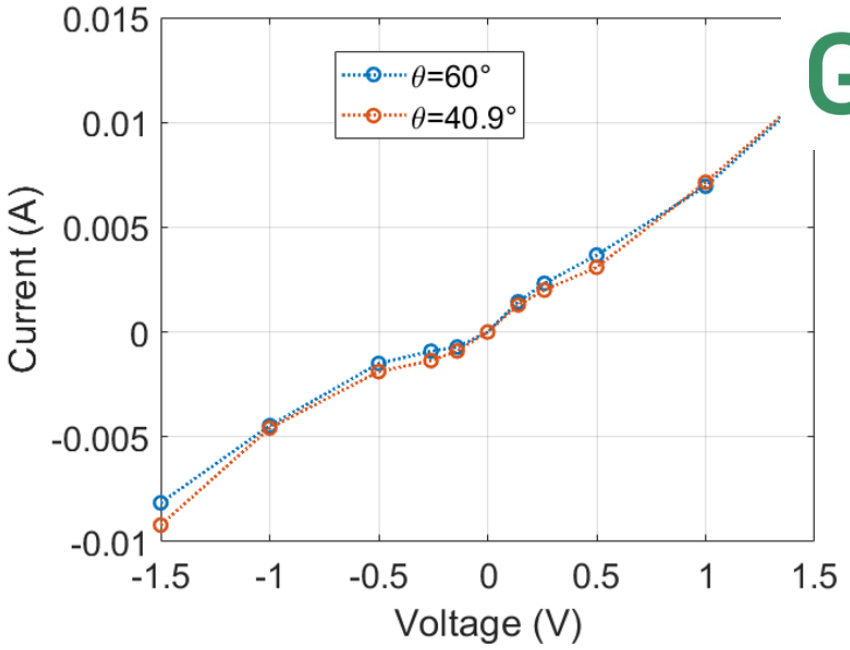
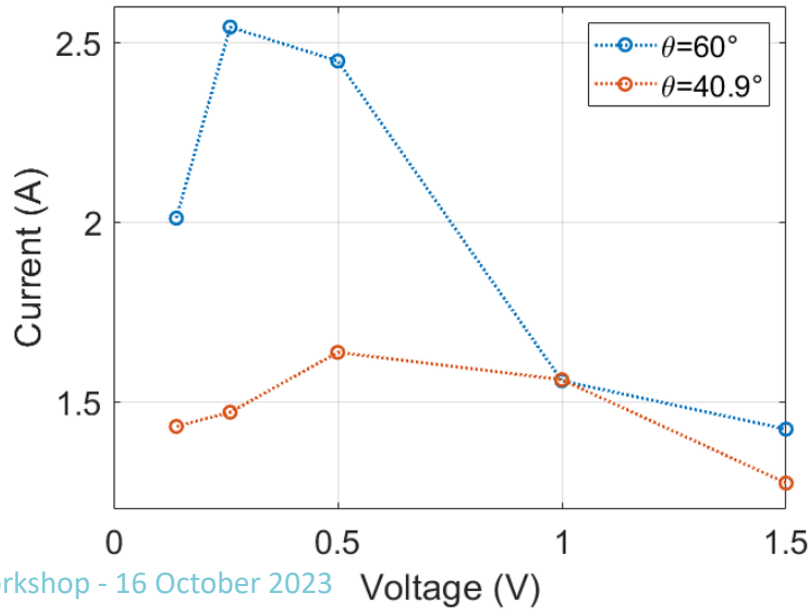


Table II

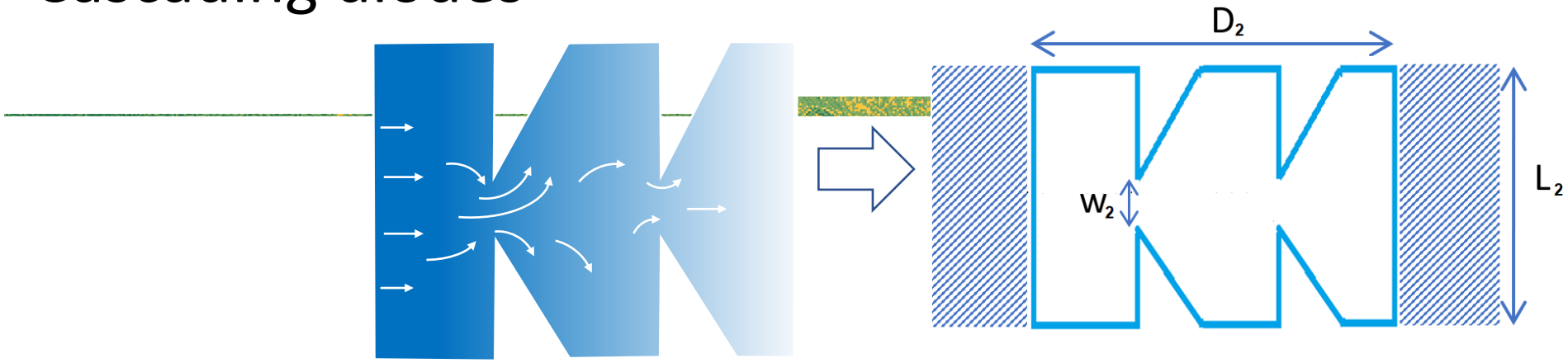
l	≈ 22.6 nm
l_1	≈ 7.3 nm
l_2	≈ 7.3 nm
w	≈ 29 nm
w_1	≈ 9.3 nm
w_2	≈ 10.4 nm
θ	≈ 41°

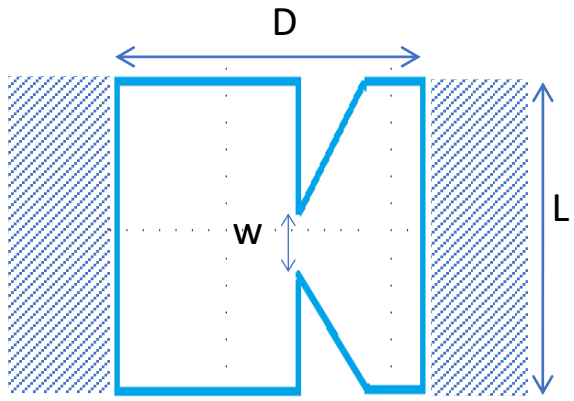




Large diodes, 23x30 nm²: two different neck angles are considered for comparison, 60° and 40.9°

Cascading diodes

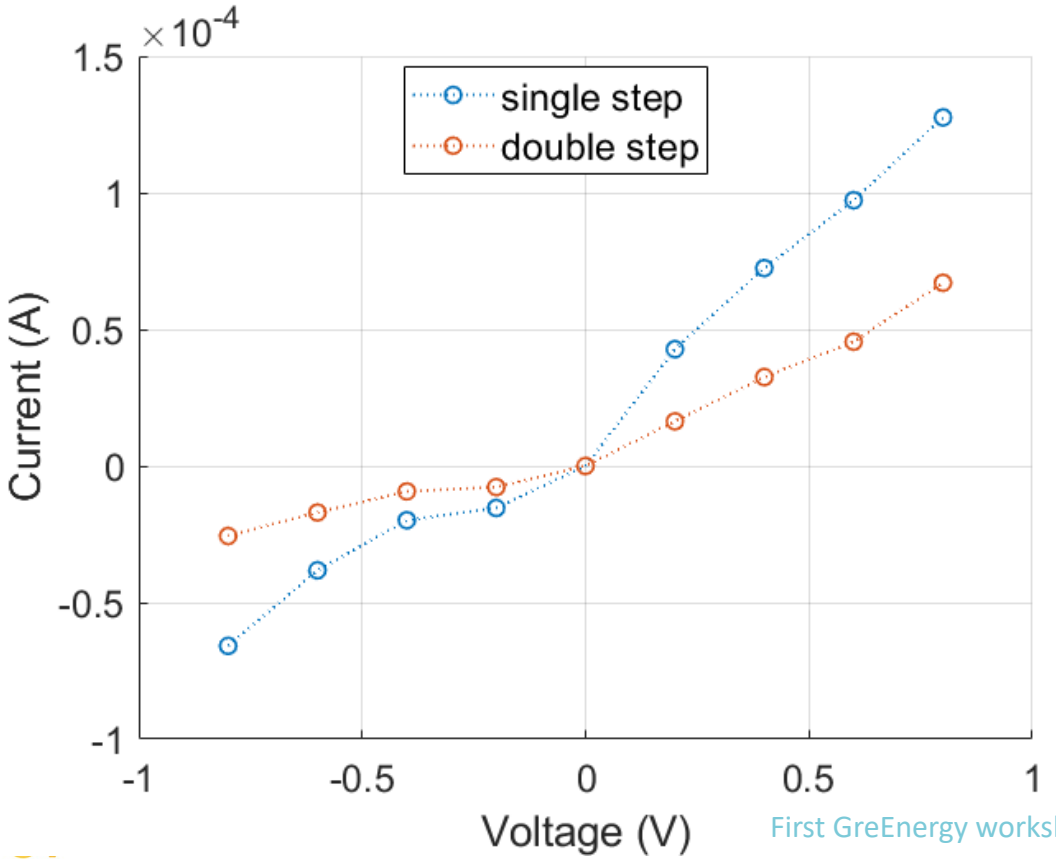


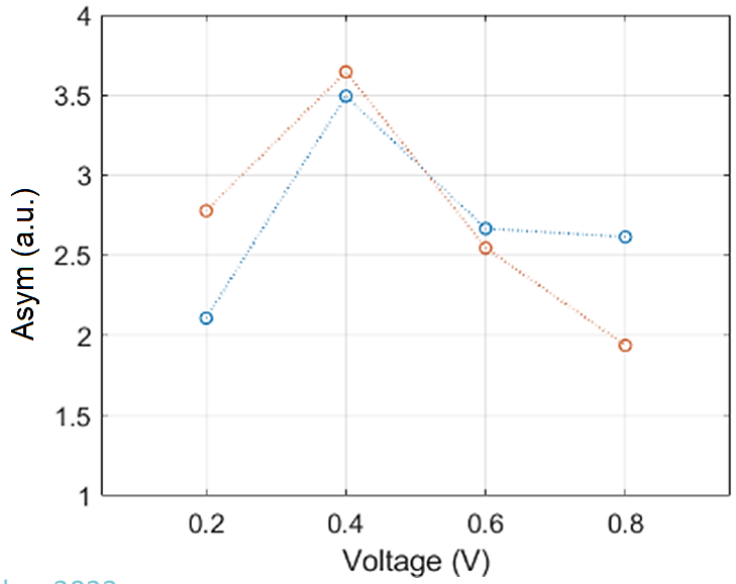


$w_2 = w = 10$ nm

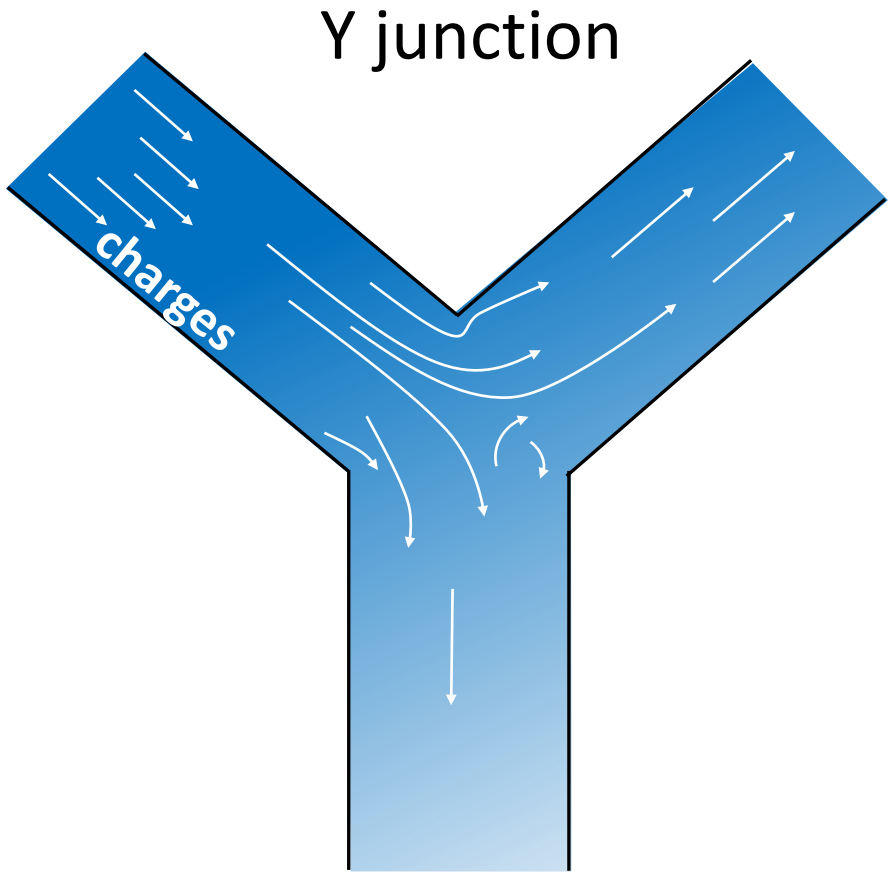
$L_2 = L = 33$ nm

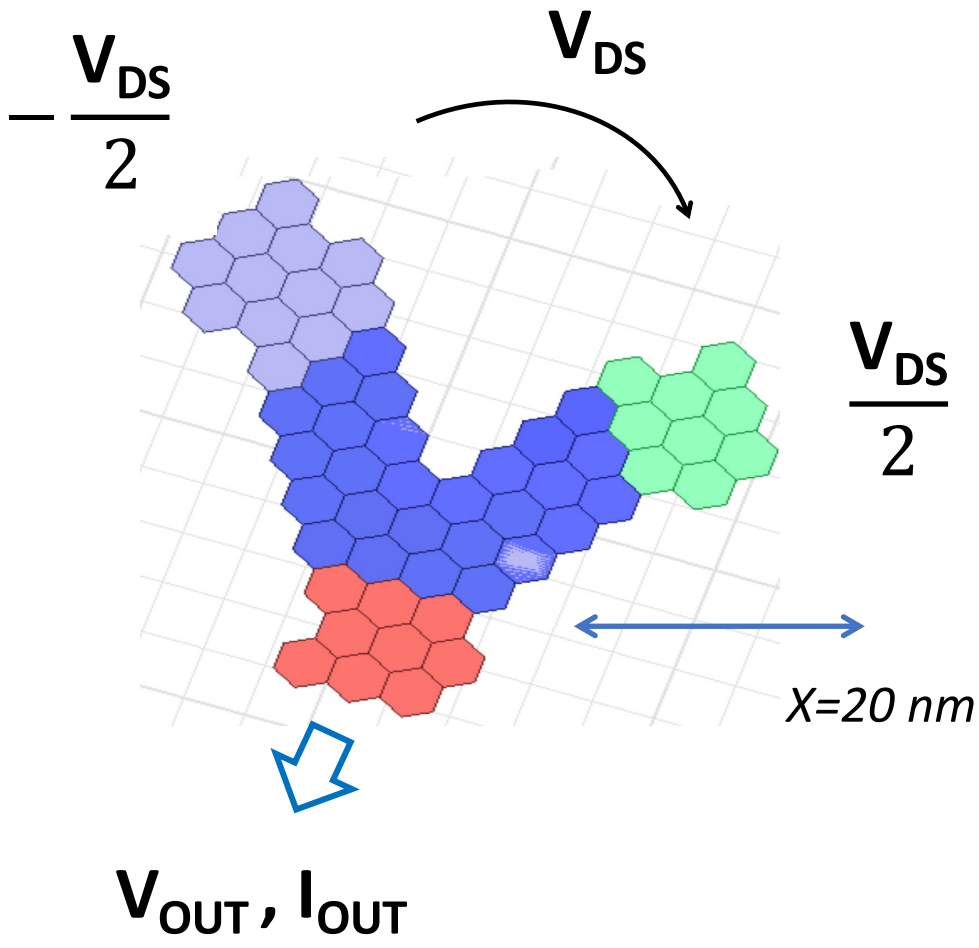
$D_2 = 2D = 60$ nm





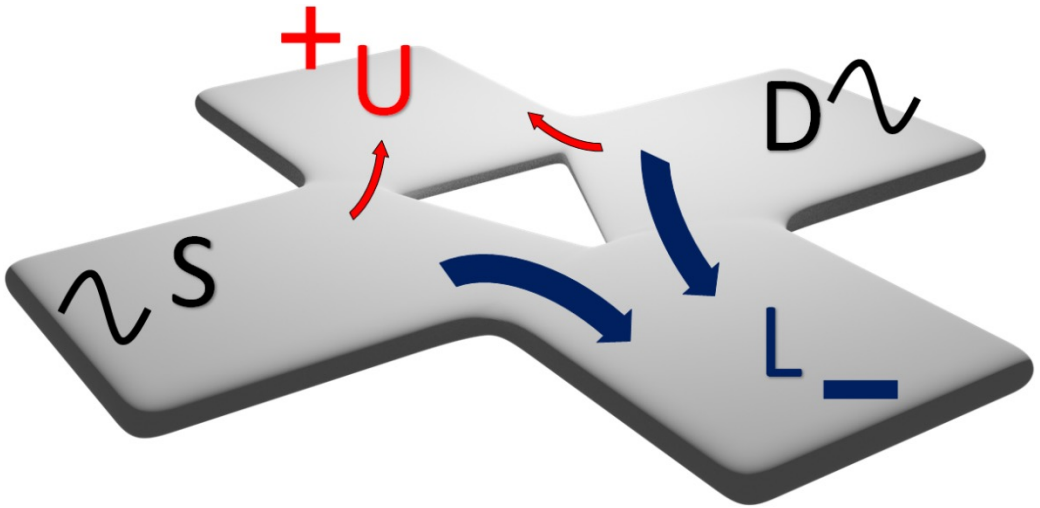
An interesting case: 3 port device (Y junction)

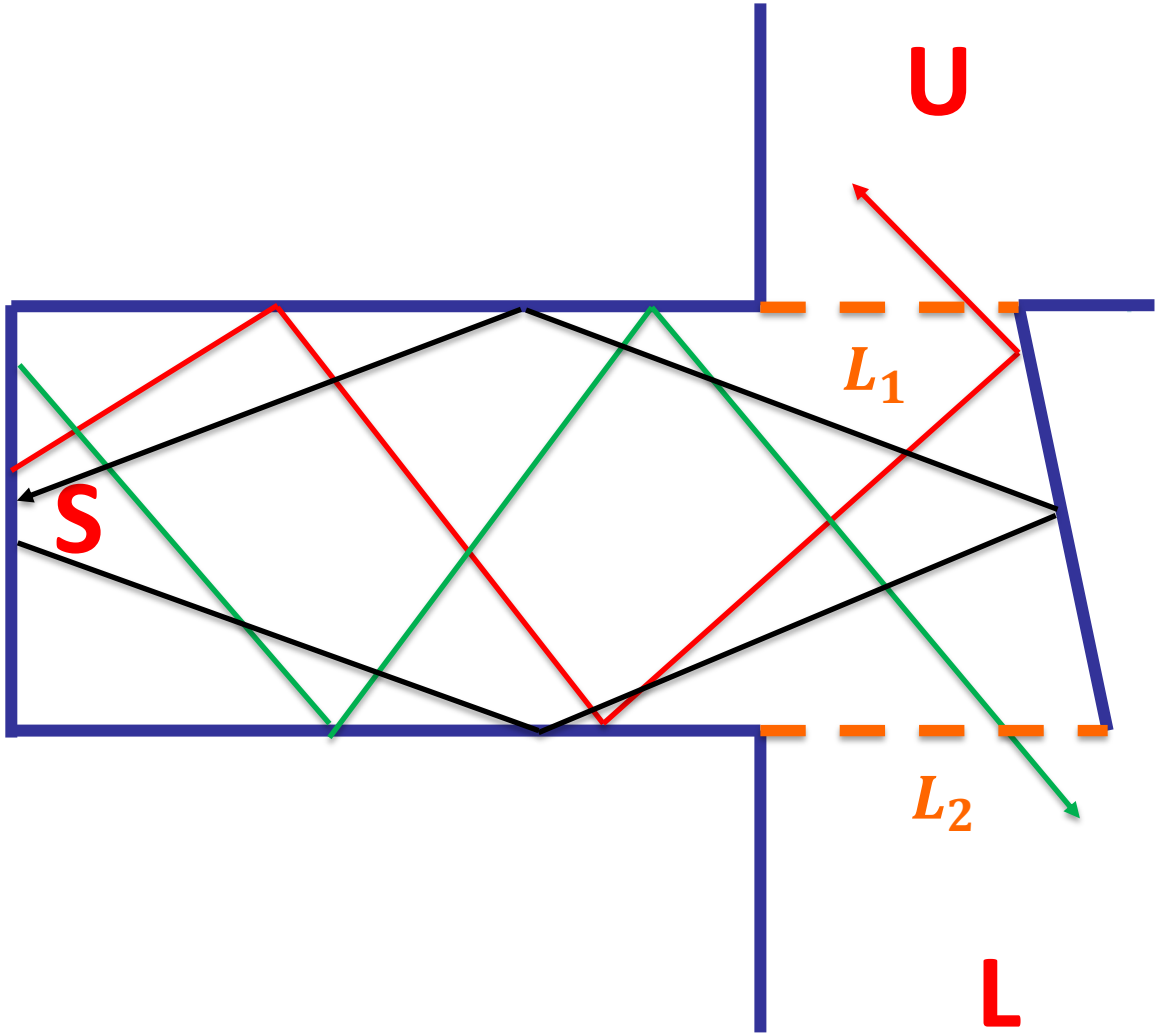




4 port BALLISTIC RECTIFIER

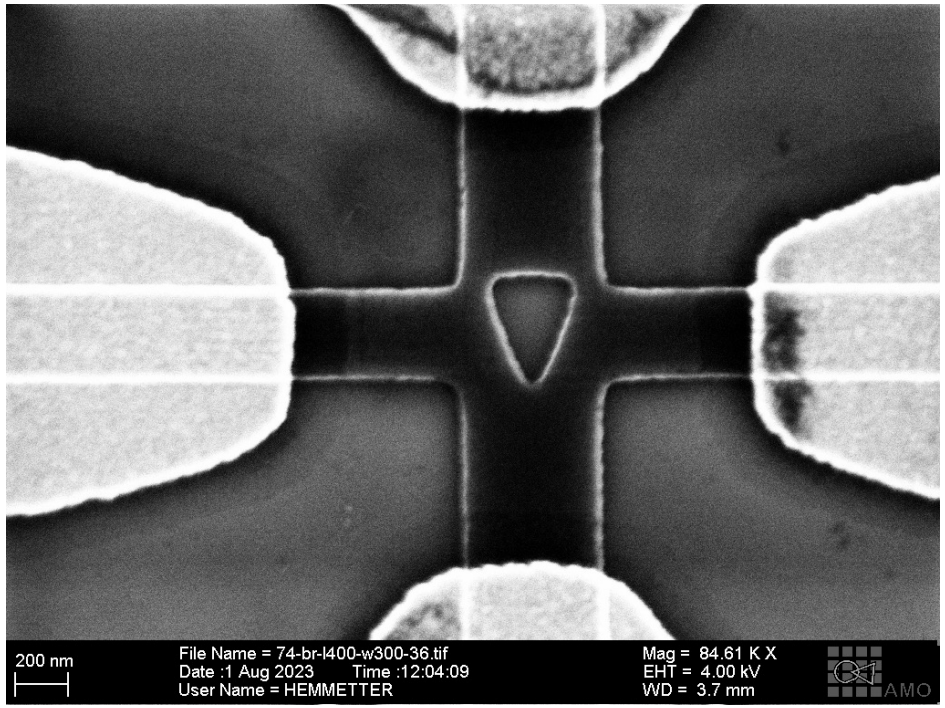
Electronic transport through Montecarlo simulations (UNIUD, in progress)

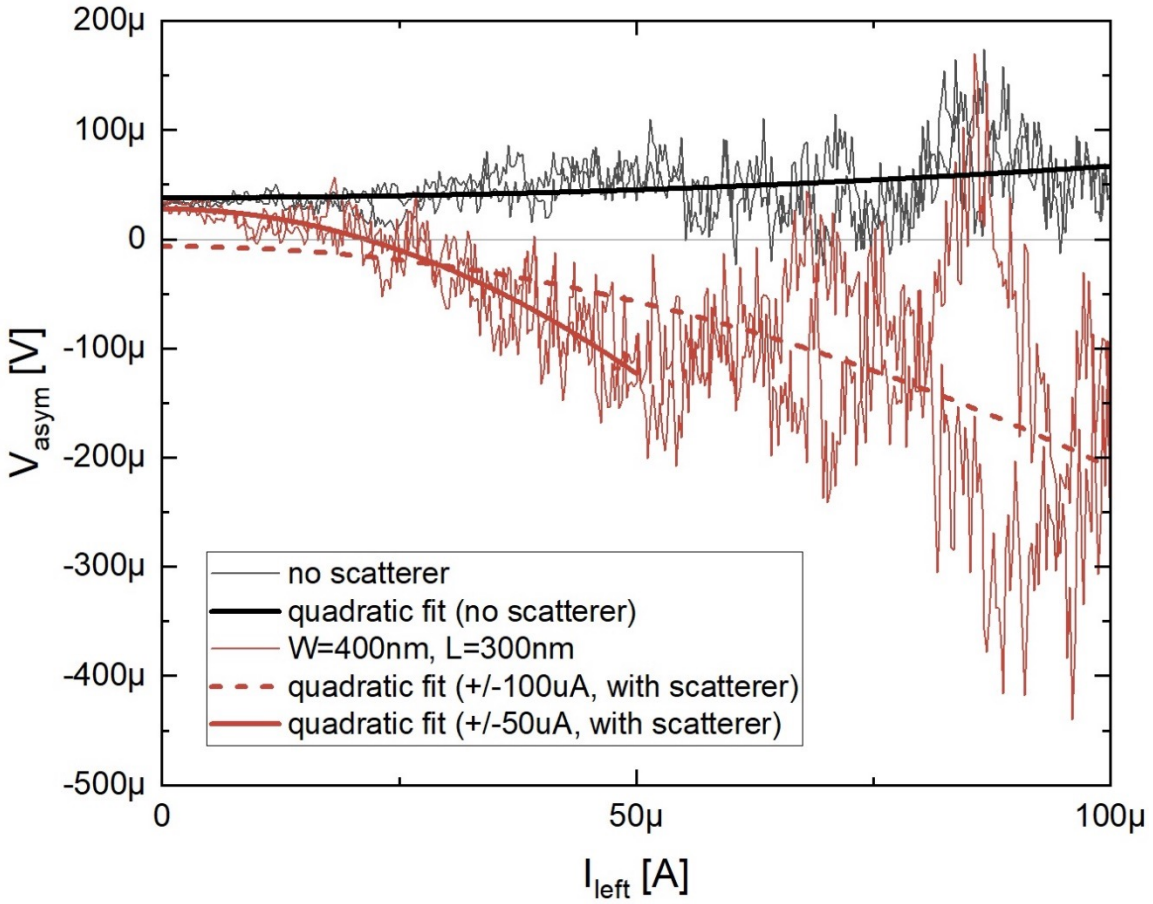




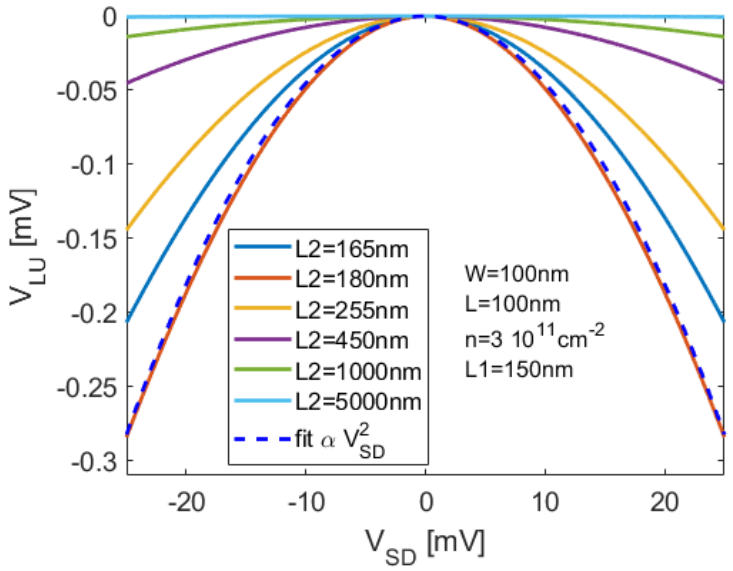
Encouraging experimental results

W=400nm, L=300nm

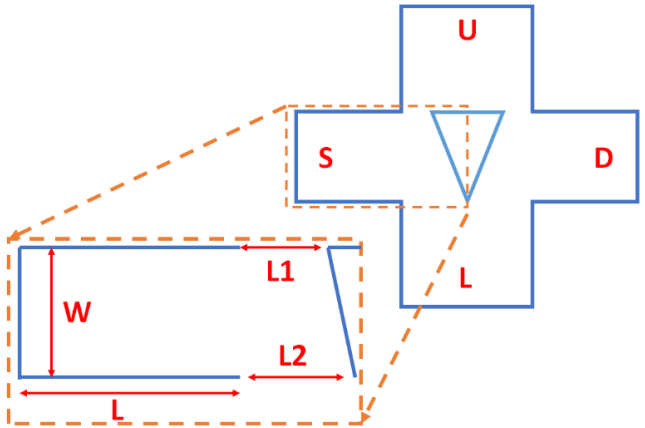


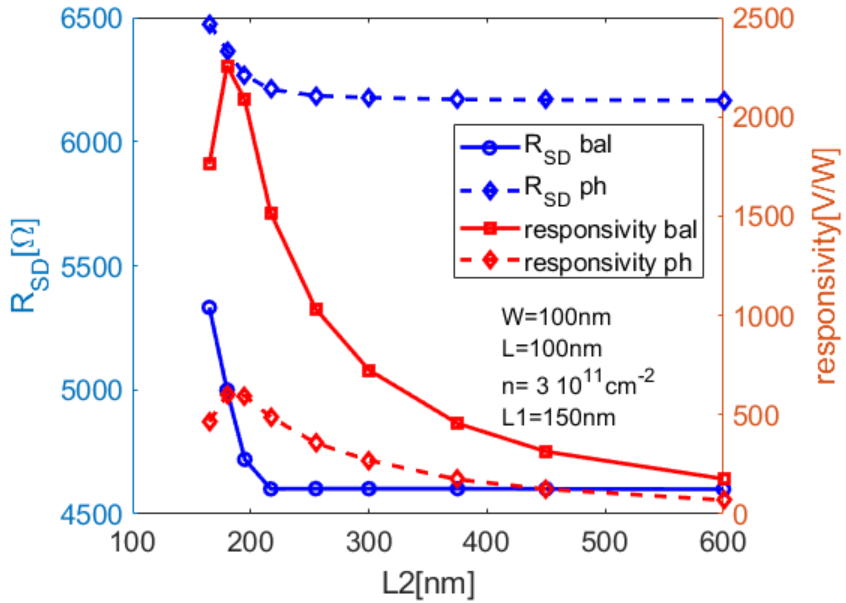


Monte Carlo results (by UNIUD)

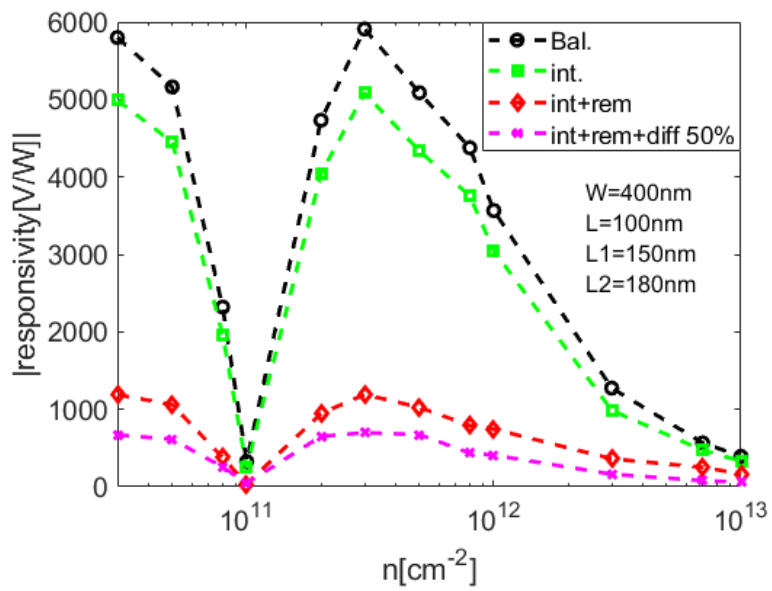


VLU (output voltage) as a function of **VSD** for different **L2** for **ballistic simulations**





Dependence of input resistance RSD and responsivity on L2. Responsivity is evaluated considering VSD near 0 V. **RSD bal** and **responsivity bal** are calculated under ballistic transport while **RSD ph** and **responsivity ph** with intrinsic and remote phonon activated.



Responsivity vs electron density. Responsivity is evaluate considering VSD near 0 V. **Black line** consider full ballistic transport**. Green line**: transport with intrinsic phonons. **Red line**: transport with intrisic + remote phonons. **Purple line**: transport with intrinsic + remote phonons + 50% of random reflecting angles.

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SCIPROM Science, Management & Communication

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Thank you for your attention

More information is available at **www.greenergy-project.eu**

GreEnergy

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