

# Coupling light into graphene plasmons with the help of surface acoustic waves

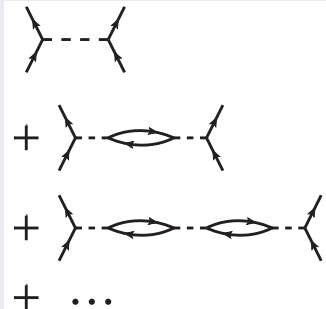
- Jürgen Schiefele
- Jorge Pedrós
- Fernando Sols
- Fernando Calle
- Francisco Guinea



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# Graphene plasmon dispersion

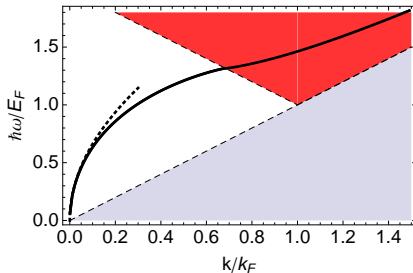
Screening: dielectric function  $\epsilon(k, \omega)$



[Wunsch *et al.*, NJP 2006]

[Hwang&Das Sarma, PRB  
2007]

Plasmon dispersion: Set  $\epsilon(k, \omega) = 0$

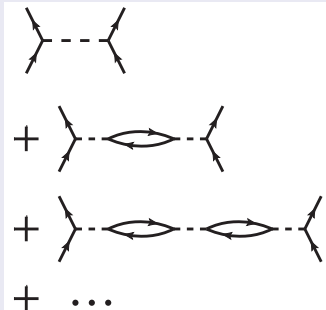


- For small  $k$ :  $\omega \propto \sqrt{k E_F}$ .
- Tuneable with  $E_F$ .

[Jablan *et al.*, PRB 2009]

# Graphene plasmon dispersion

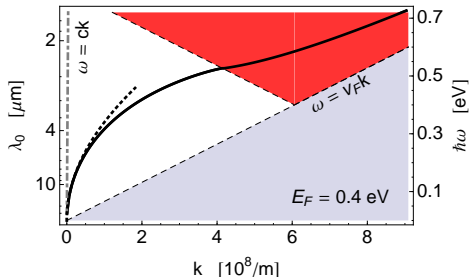
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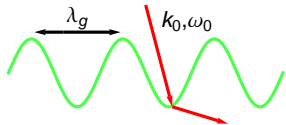


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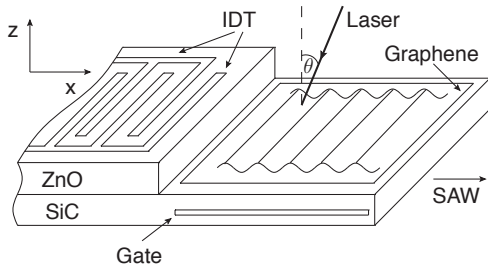
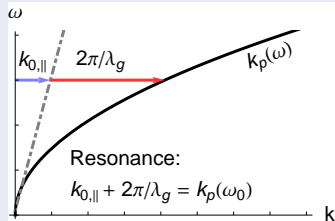
[Jablan *et al.*, PRB 2009]

# A switchable grating for plasmon laser coupling

- Electrically excite a diffraction grating.

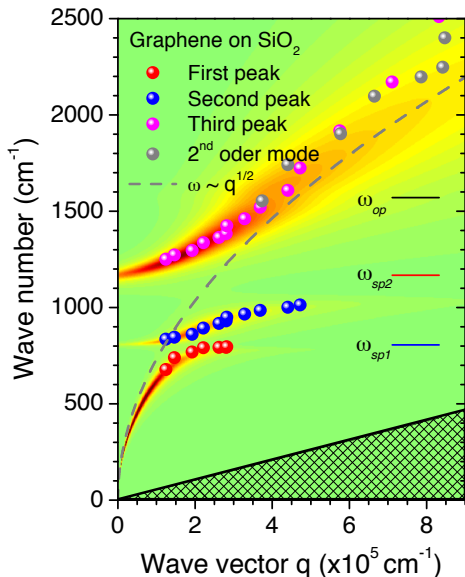


## Plasmon-Laser resonance



[Ruppert *et al.*, PRB 2010]

# Graphene on a polar substrate – plasmon hybridization



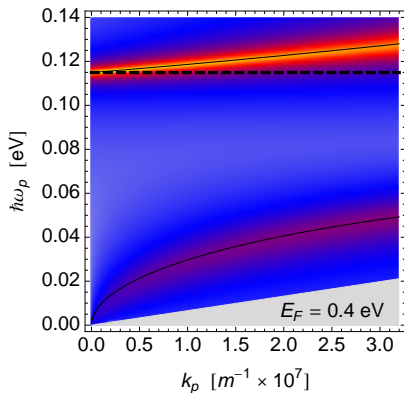
Taken from

[Yan *et al.*, arXiv:1209.1984]

# Laser-plasmon resonance

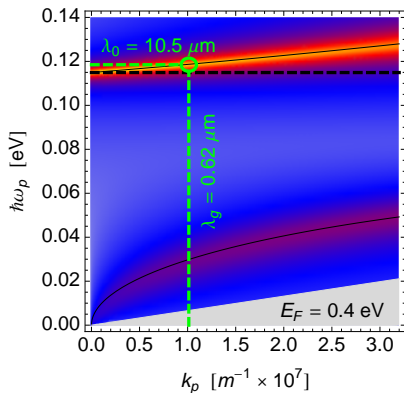
- Plasmon dispersion (on SiC):

- Resonance condition:

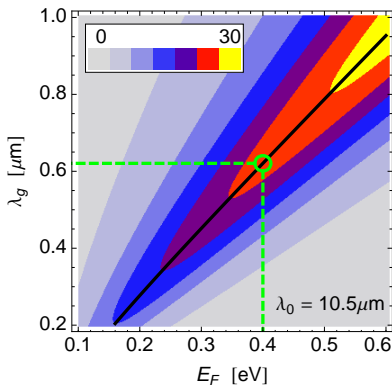


# Laser-plasmon resonance

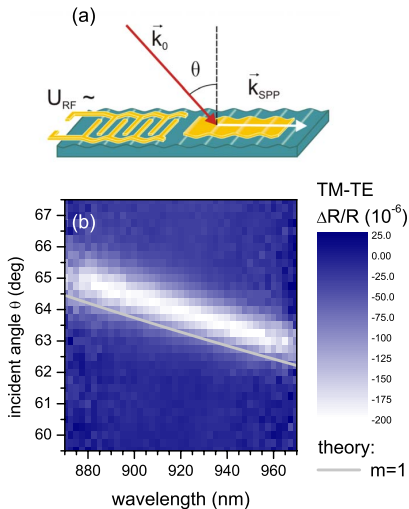
- Plasmon dispersion (on SiC):



- Resonance condition:



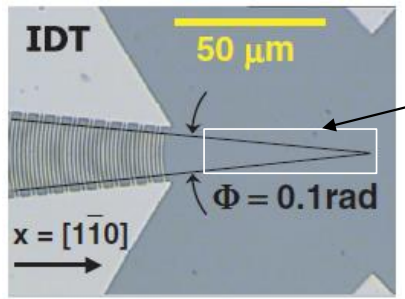
# SAW assisted plasmon launching – in noble metals



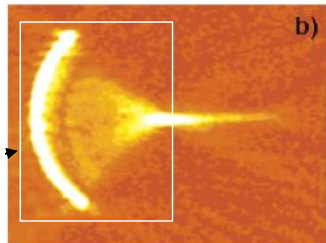
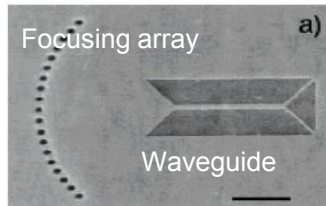
[Ruppert *et al.*, PRB 2010]



# Other functionalities – plasmon focusing



[Lima *et al.*, Rep. Prog. Phys. 2005]



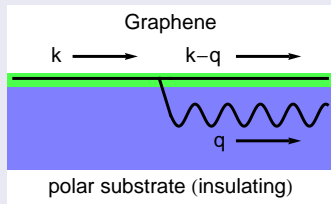
[Yin *et al.*, Nano Lett. 2005]

- SAWs generate dynamic gratings for far-field plasmon excitation.
- No graphene patterning involved.
- Switchable plasmon launcher.
- IDT technology and SAW interference enables complex plasmonic functionalities.



# Graphene on a polar substrate – plasmon hybridization

## Remote phonon scattering



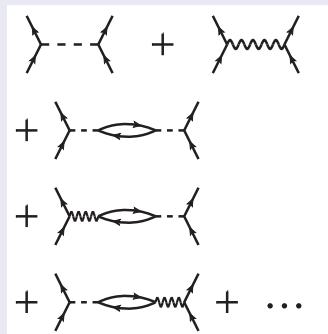
- Graphene carriers couple to optical substrate phonons.

[Mori&Ando, PRB 1989]

[Fratini&Guinea, PRB 2007]

[Schiefele *et al.*, PRB 2012]

## Screening & dielectric function



- Setting  $\epsilon(k, \omega) = 0$  yields hybridized plasmon - phonon dispersion.