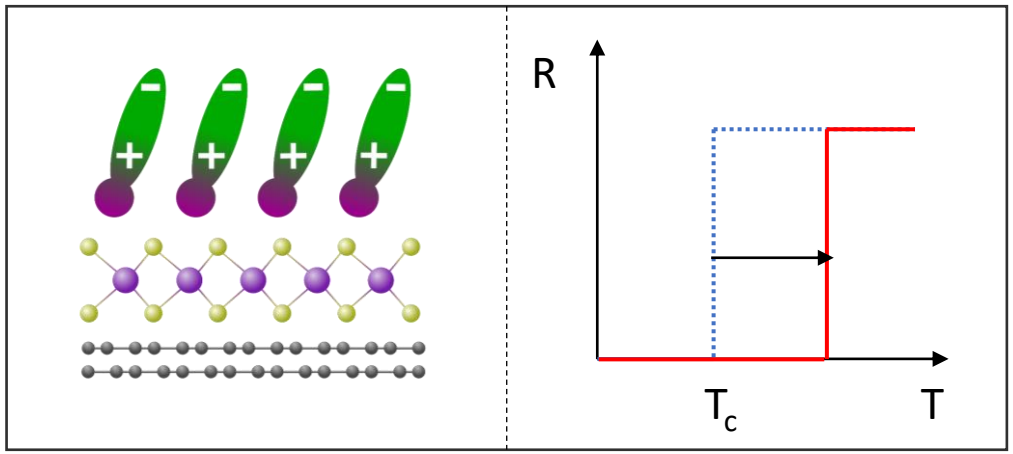
chem2Dmat

August 31 - September 03, 2021 ● ONLINE

European Conference on Chemistry of Two-Dimensional Materials



Tuning superconductivity in large-area $NbSe_2$ monolayers via molecular functionalization

Marco Gobbi

CIC nanoGUNE Consolider

Materials Physics Center

San Sebastian, Spain

CIC nanoGUNE

MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

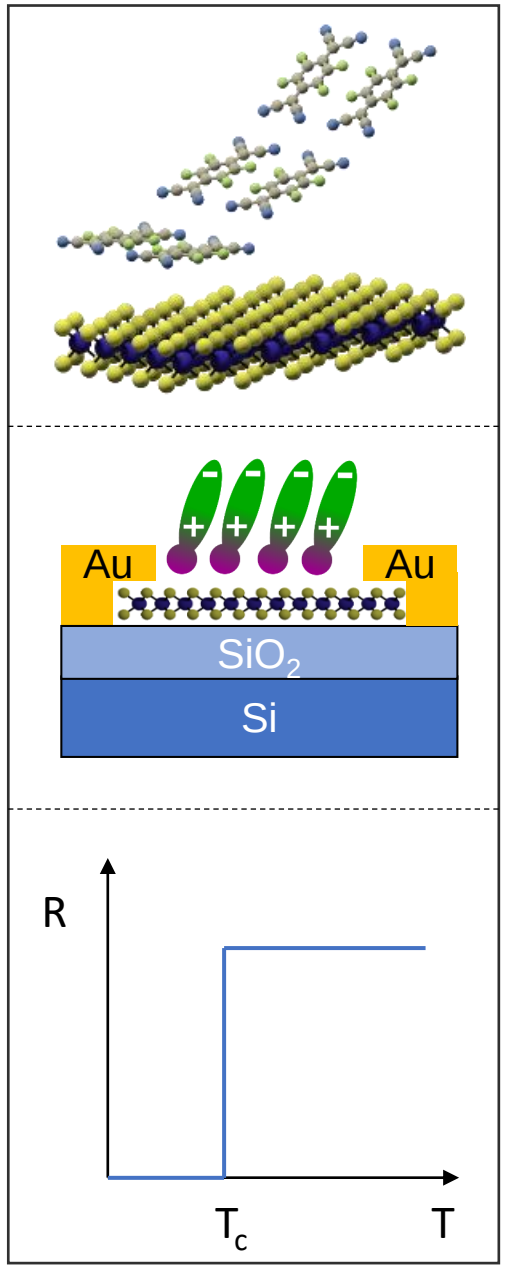
Outline

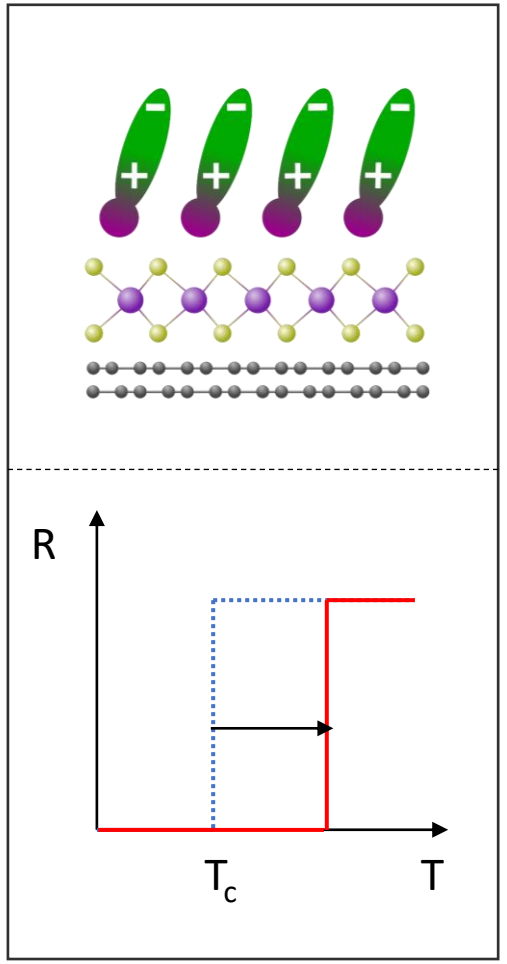
Introduction

- 2D Materials and molecules
- Molecular functionalization for electronics
- Superconductivity in 2D Materials: $NbSe_2$

Modification of superconductivity in large area $NbSe_2$

- Self-assembled adlayers
- Controllable modification in the critical temperature





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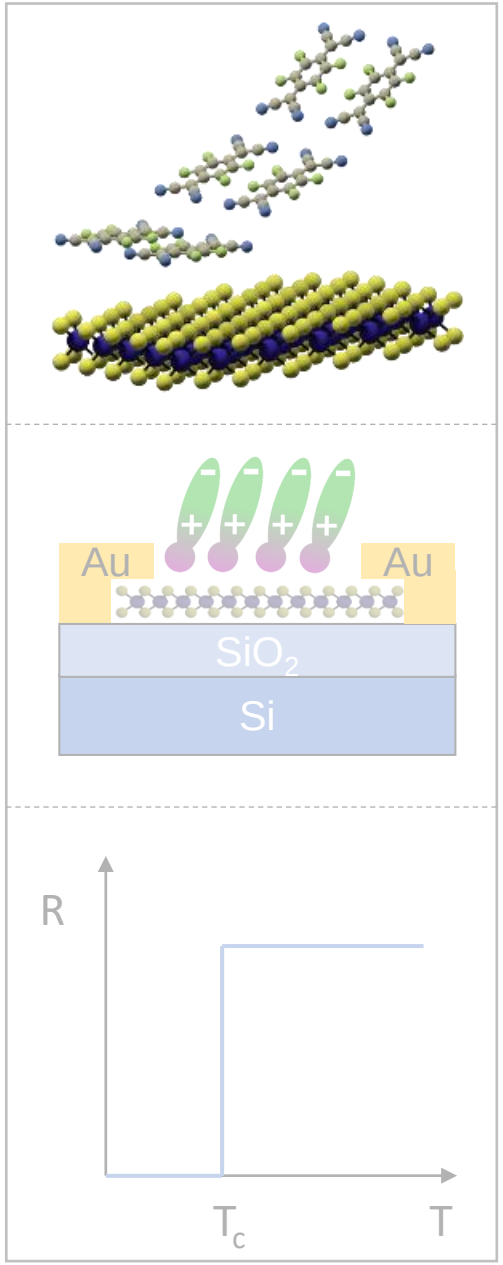

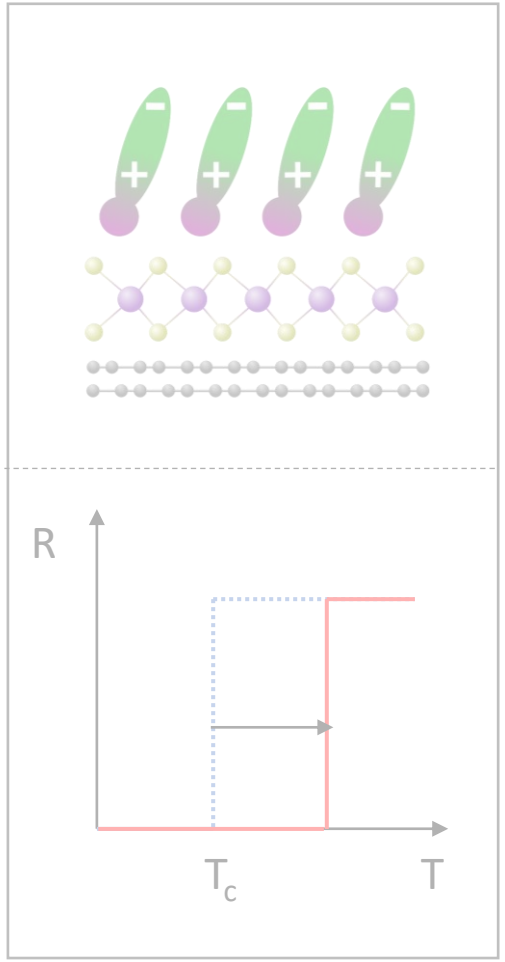

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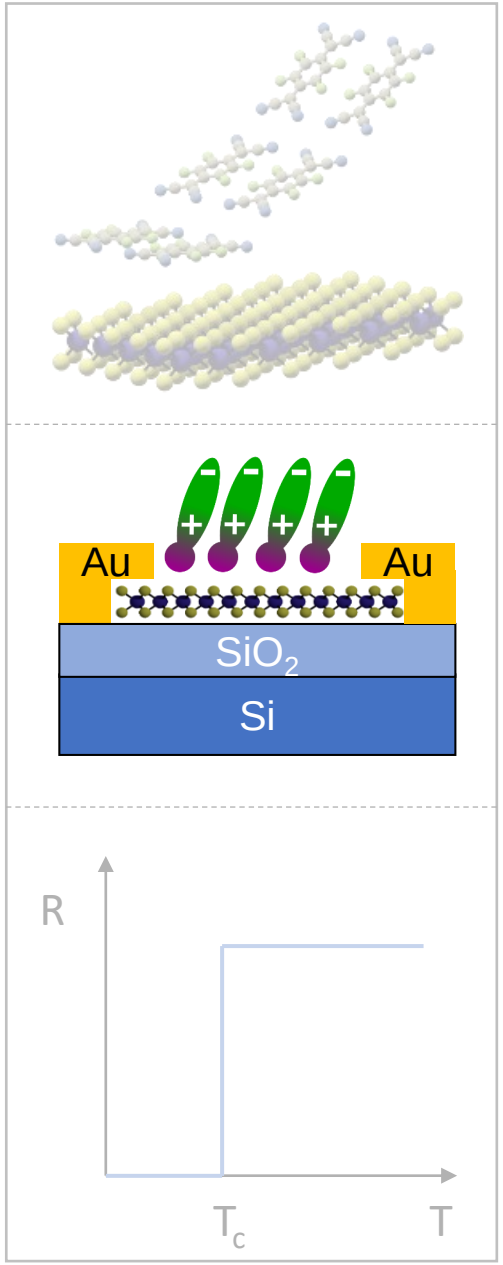

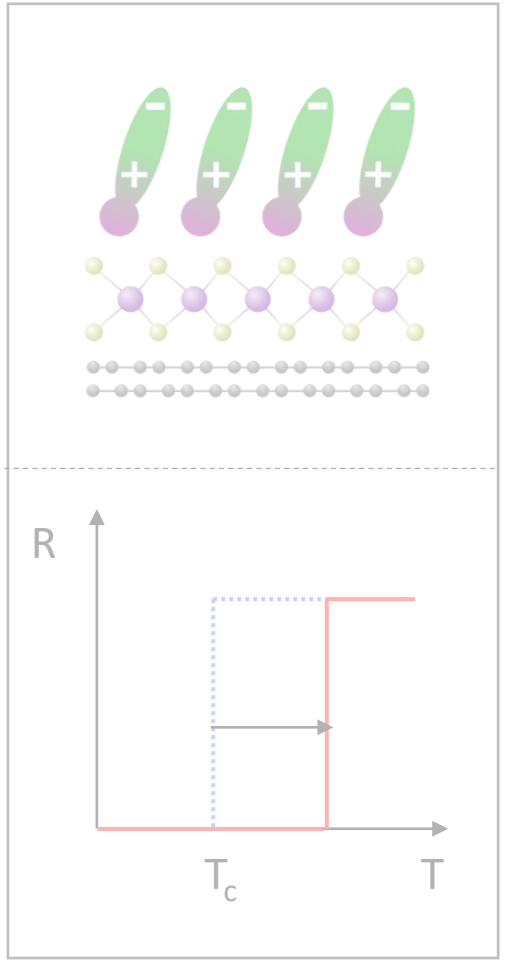

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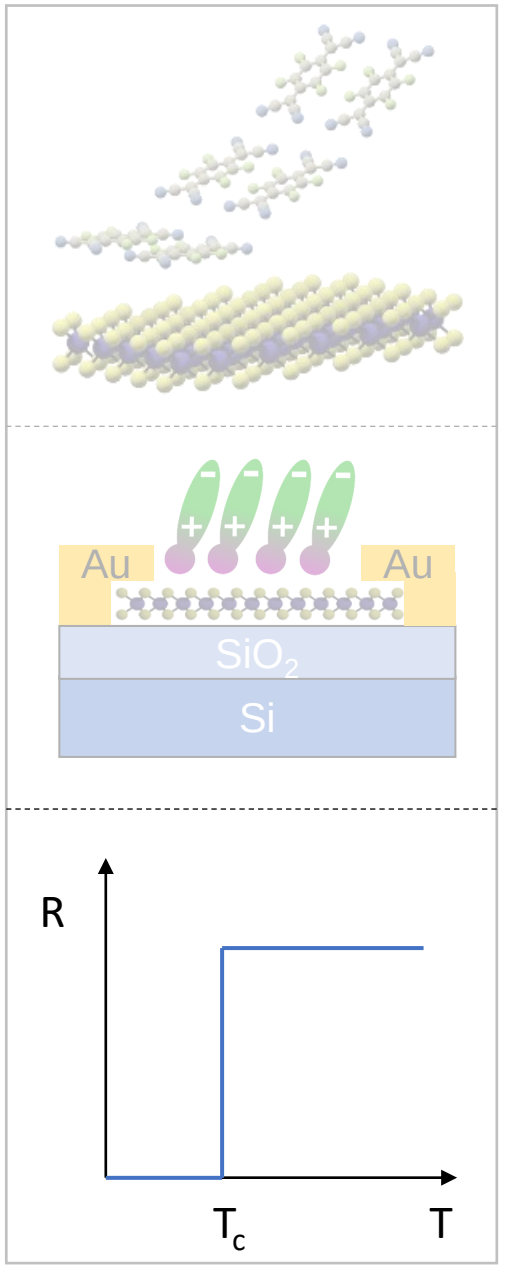

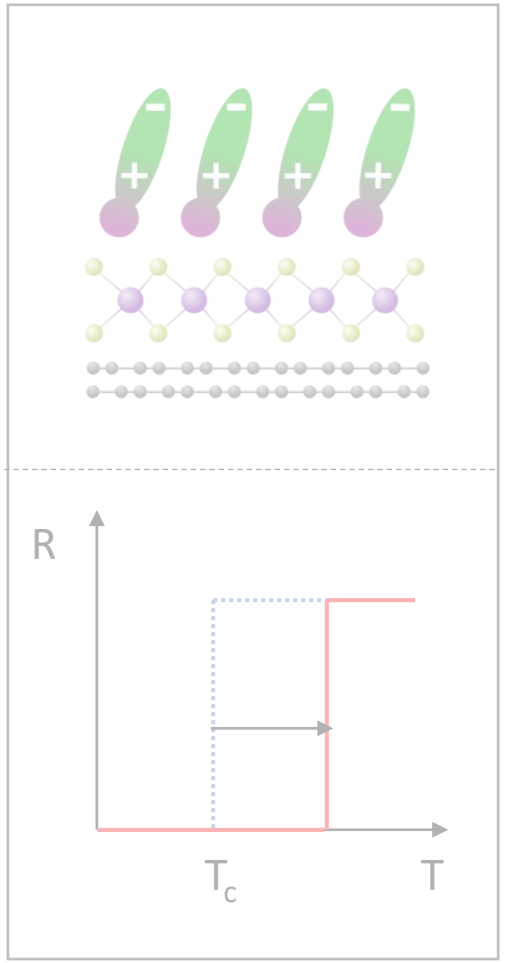

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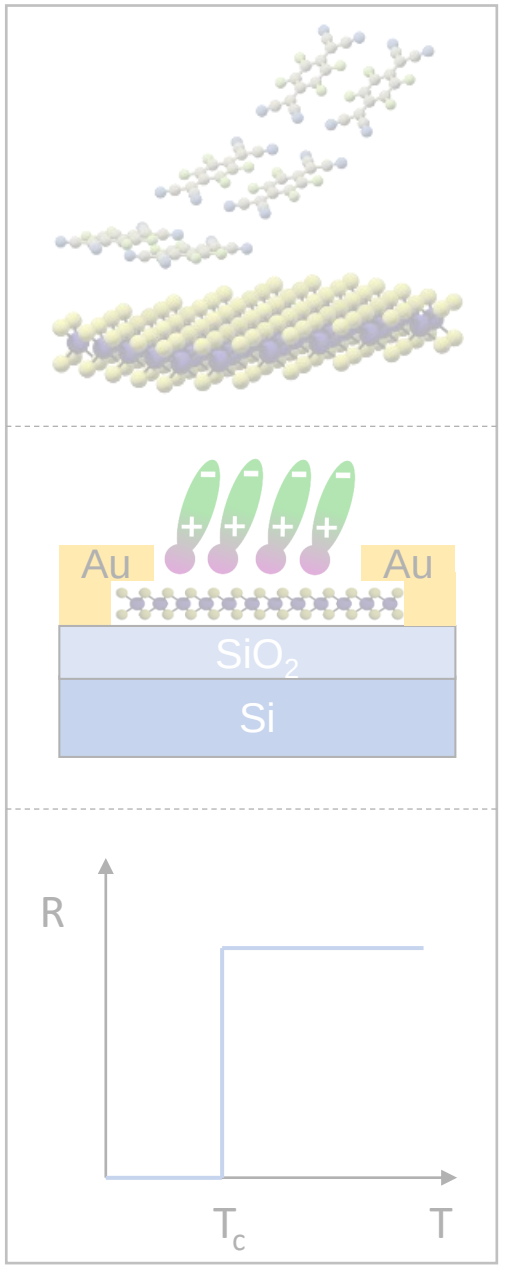

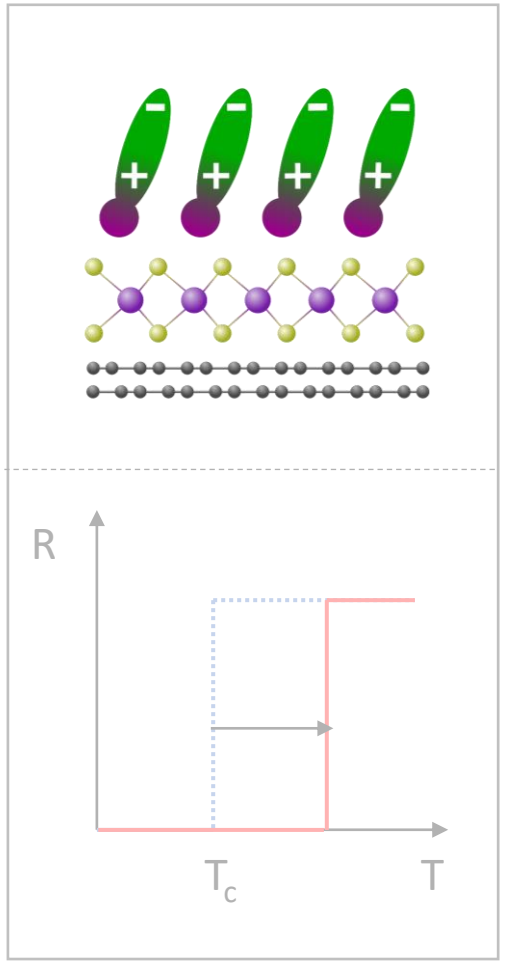

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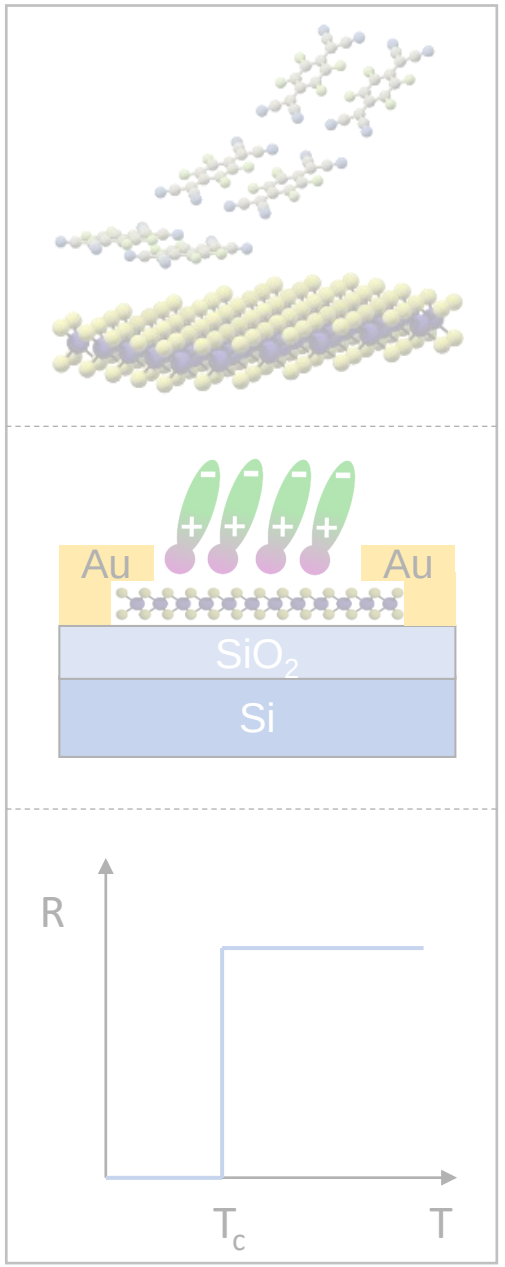

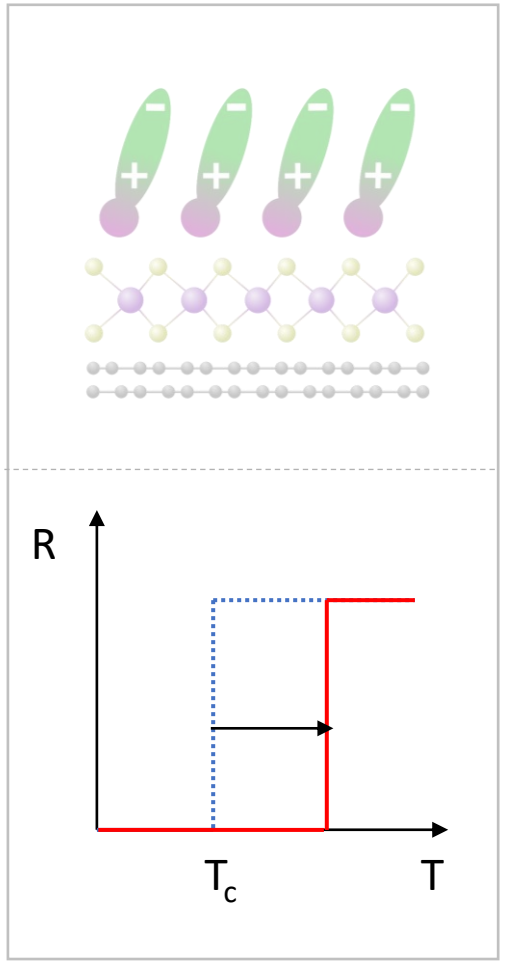

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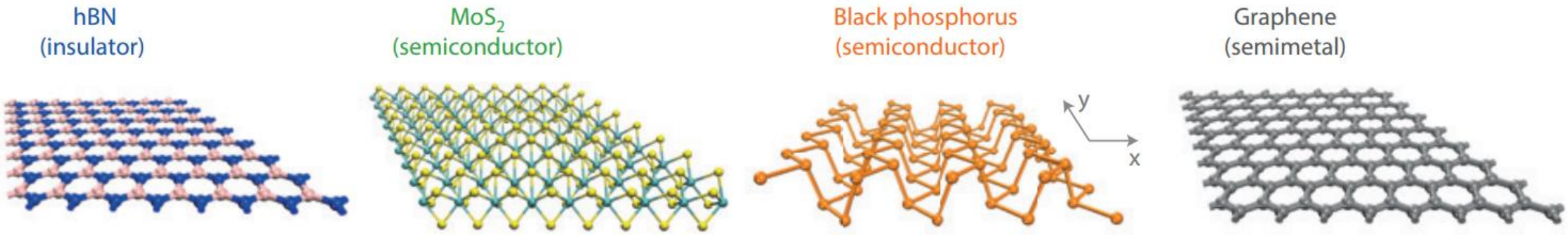
2D Materials and molecules

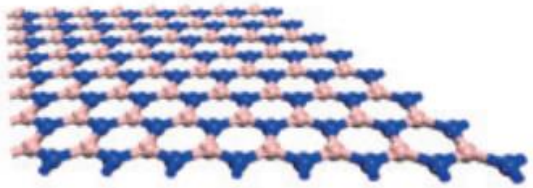


Ultra-high surface sensitivity

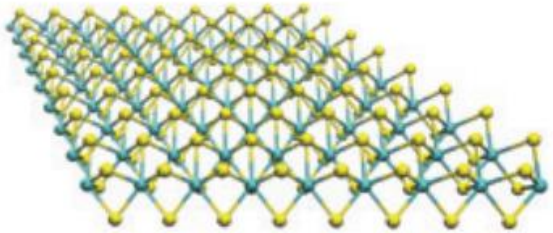
F. Xia et al., *Nature Photonics* **8**, 899–907 (2014)

2D Materials and molecules

hBN
(insulator)

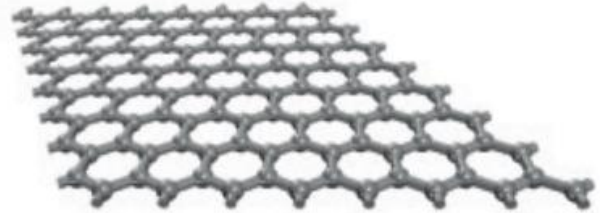


MoS_2
(semiconductor)



Black phosphorus
(semiconductor)

Graphene
(semimetal)



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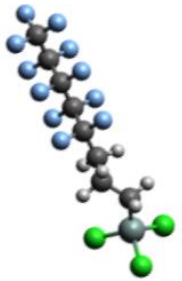
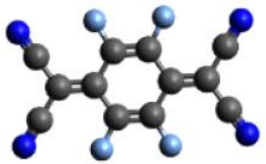
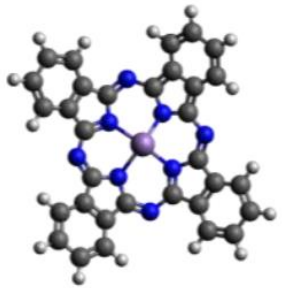


Fluorinated silane
(electrical dipole, predictable self-assembly)



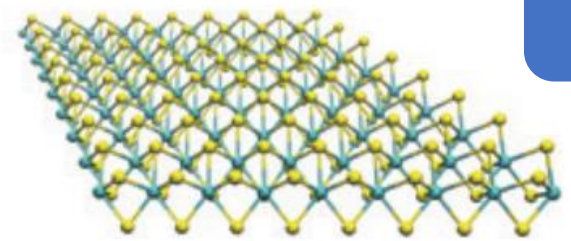
F_4TCNQ
(electron acceptor)



Metal-phthalocyanine
(predictable spin configuration)

Function by design

2D Materials and molecules

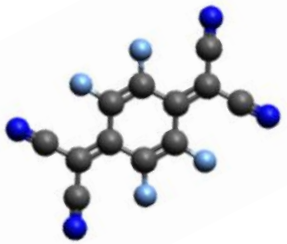


2D Materials

Tunable electronic properties

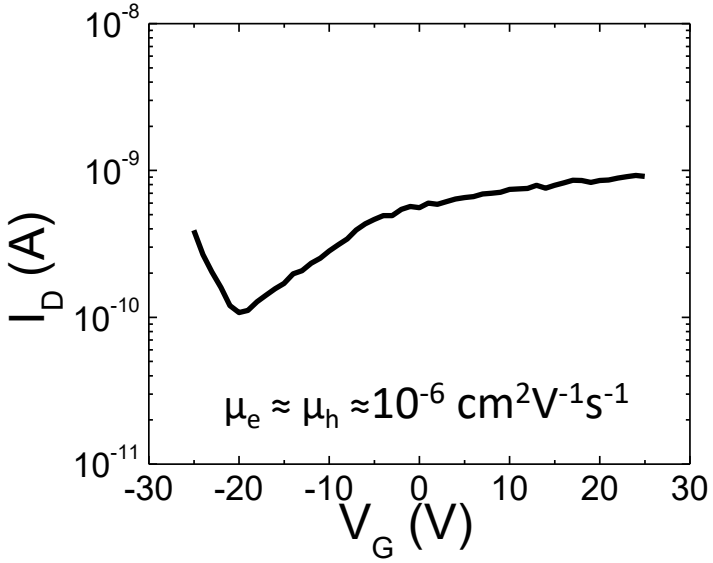
Molecules

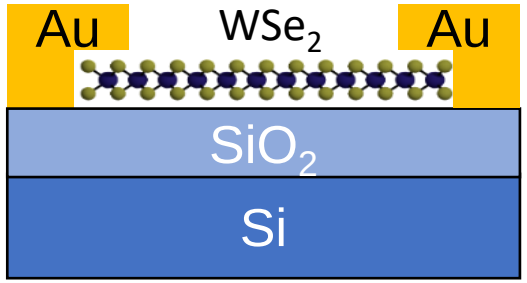
Chemical flexibility



High performance devices

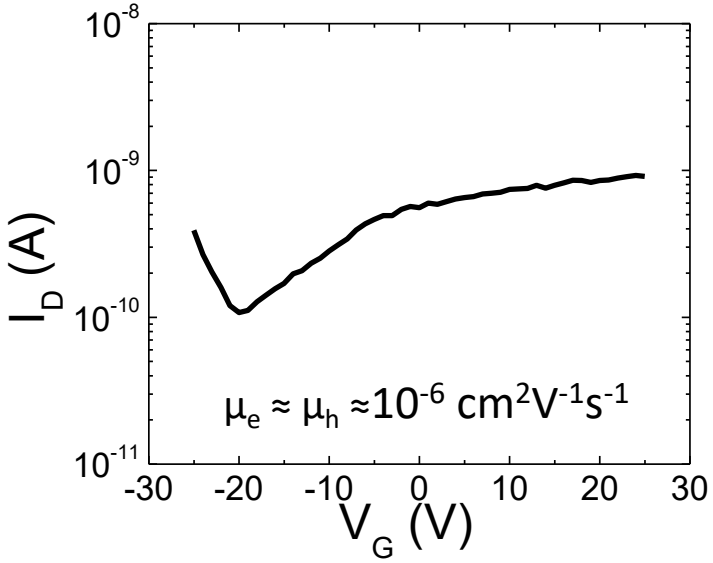
2D Materials and molecules

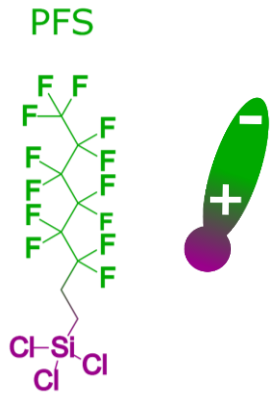


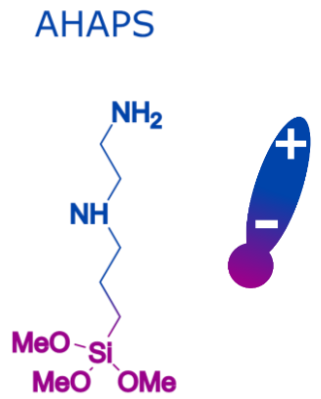


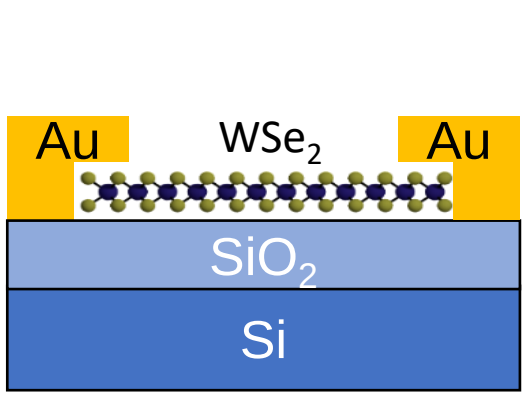
M.-A- Stoekel, M. Gobbi et al., **ACS Nano** 13, 11613 (2019)

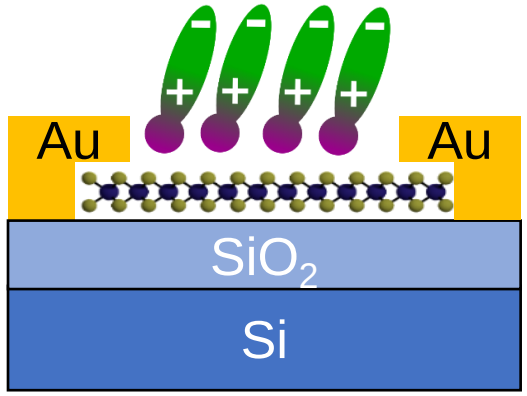
2D Materials and molecules

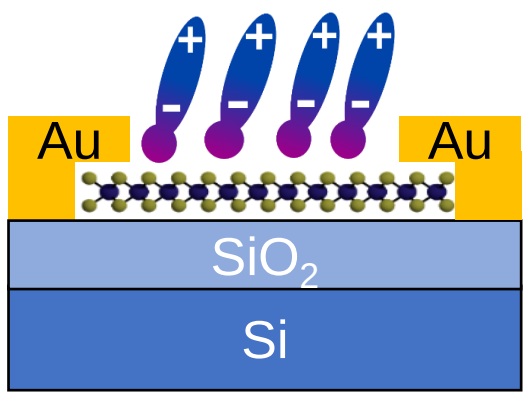












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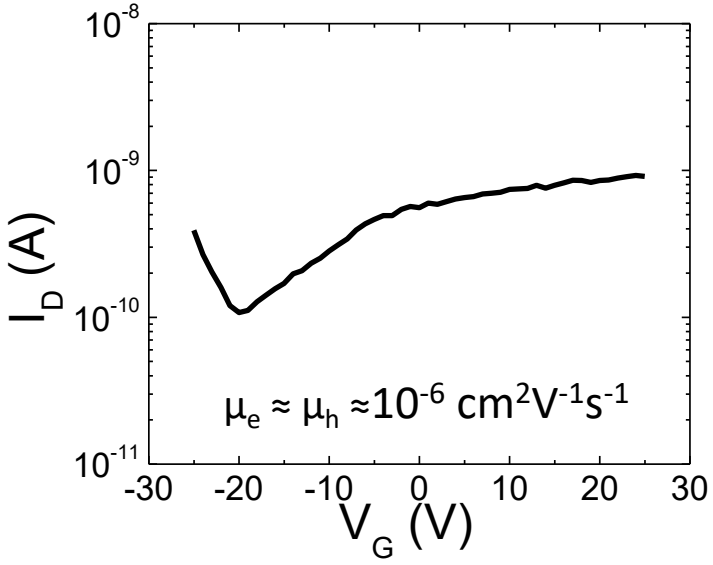

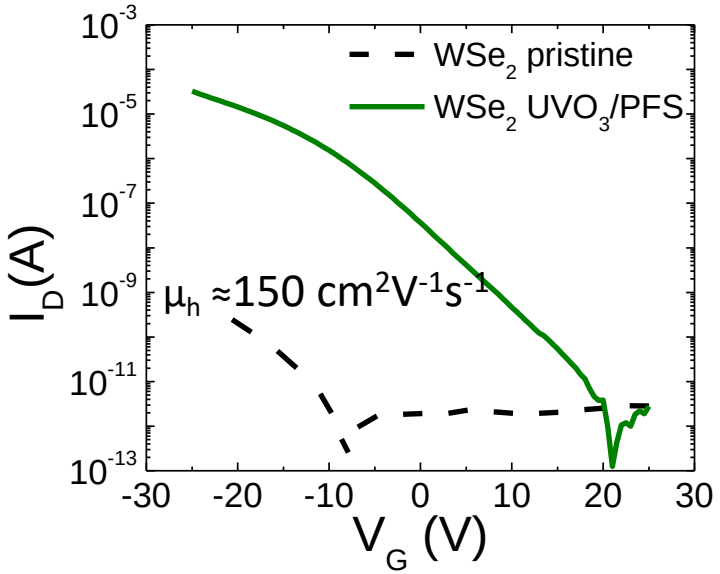

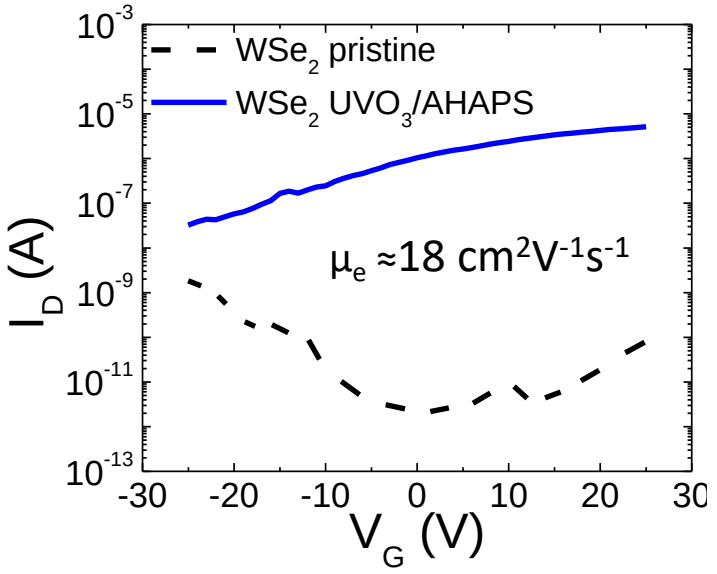

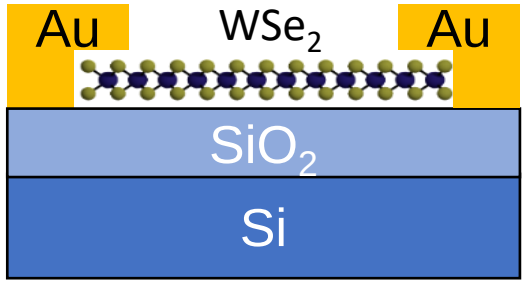

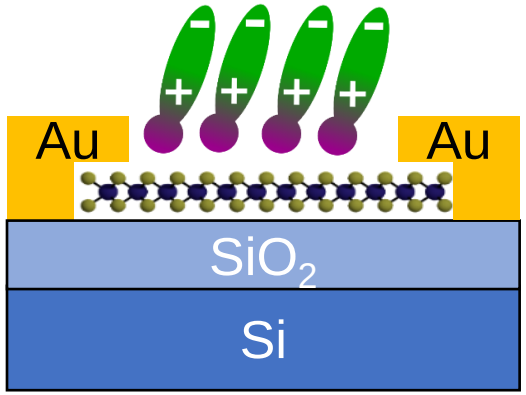

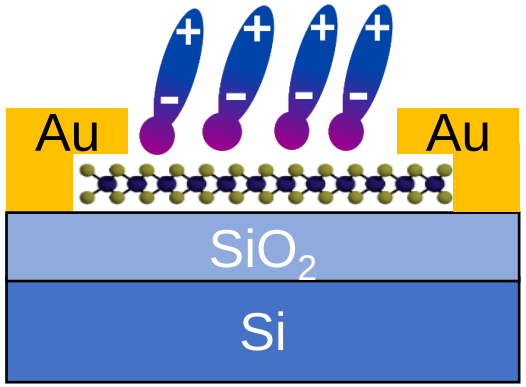

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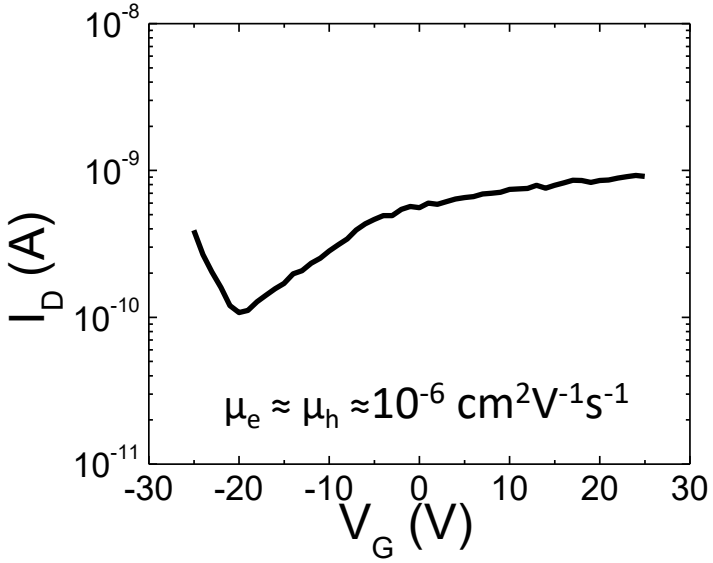
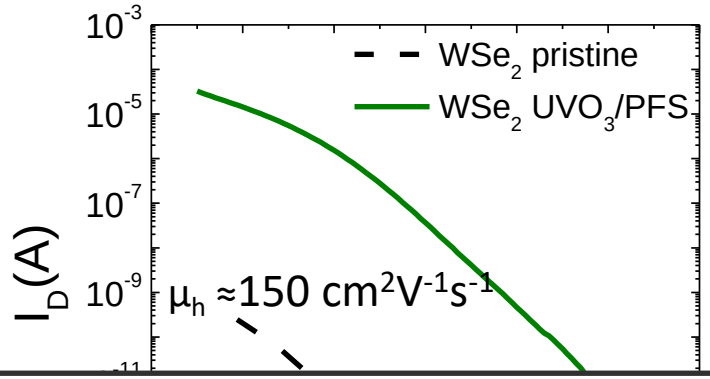
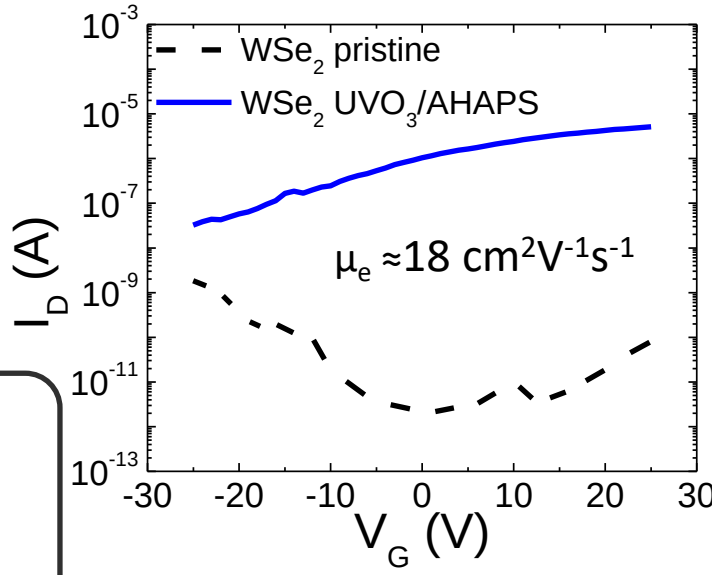
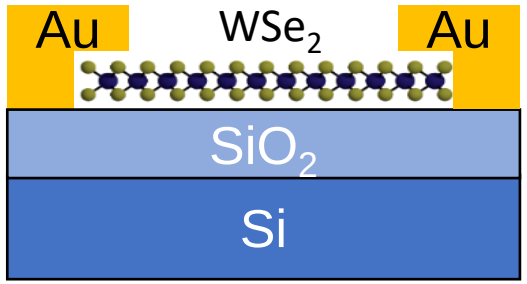
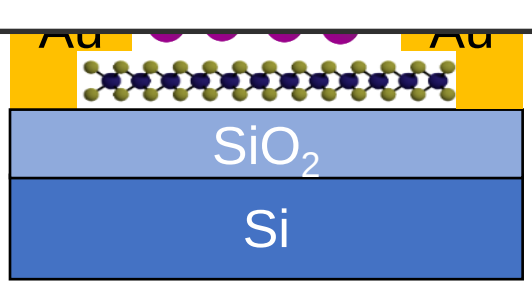


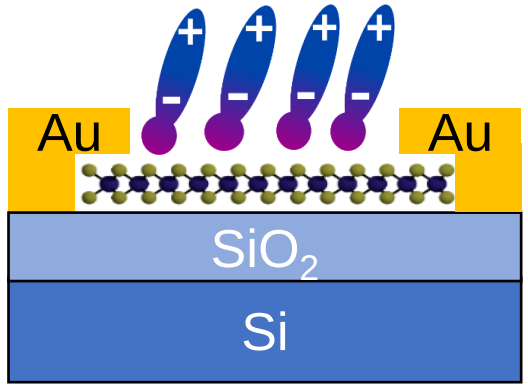




Can we use molecules to tune intrinsic properties of 2DMs?







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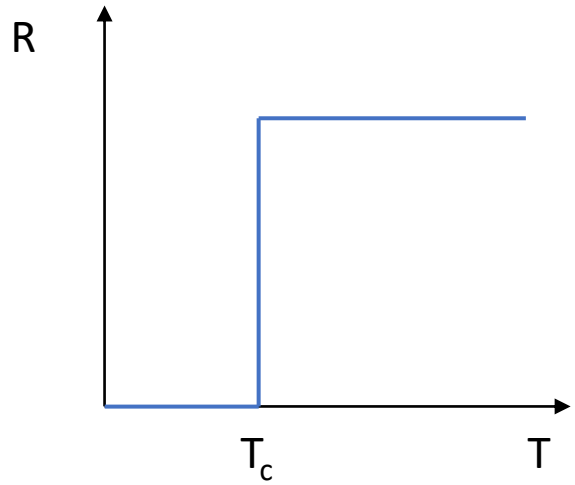
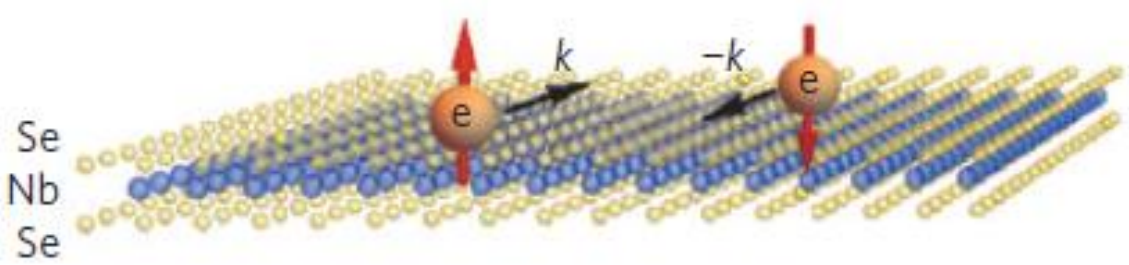
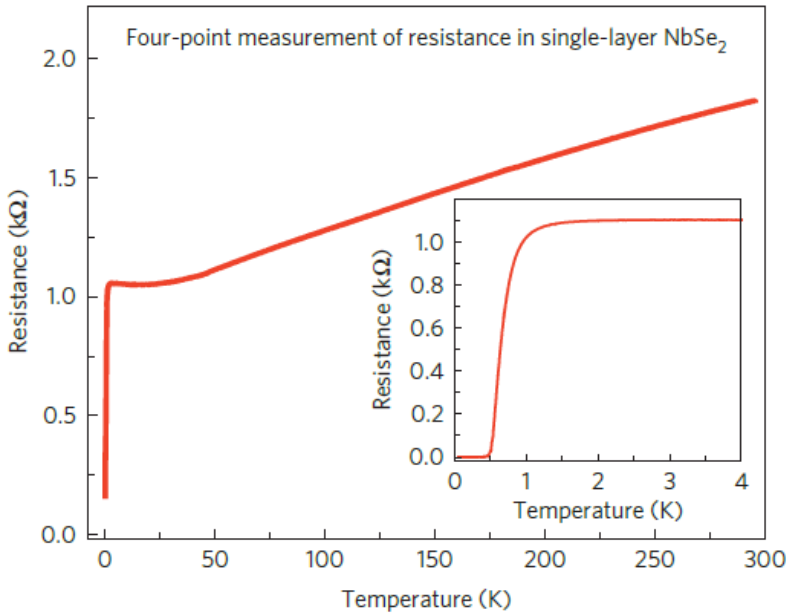
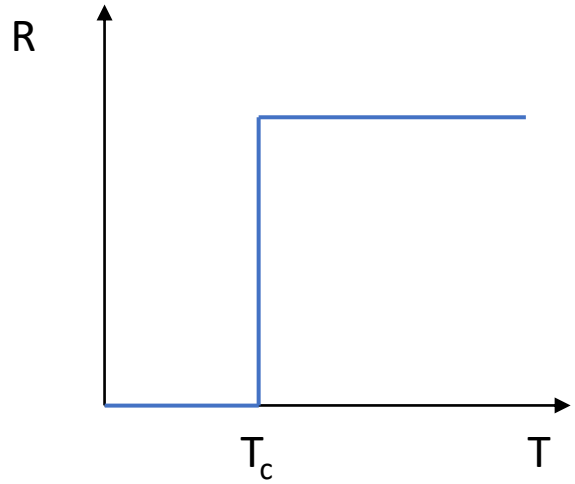
Superconductivity



Superconductivity in 2D Materials: $NbSe_2$







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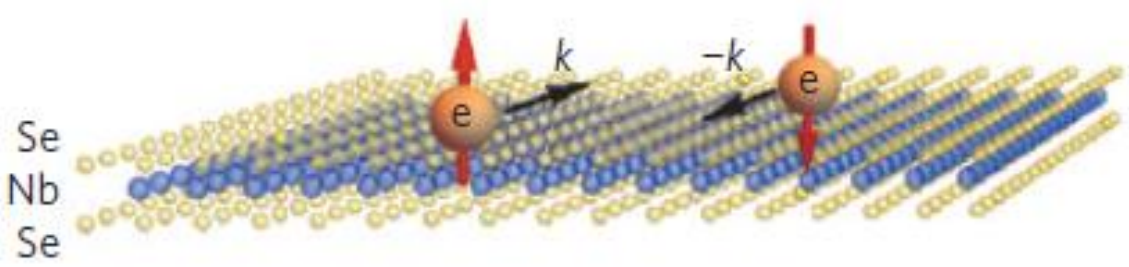

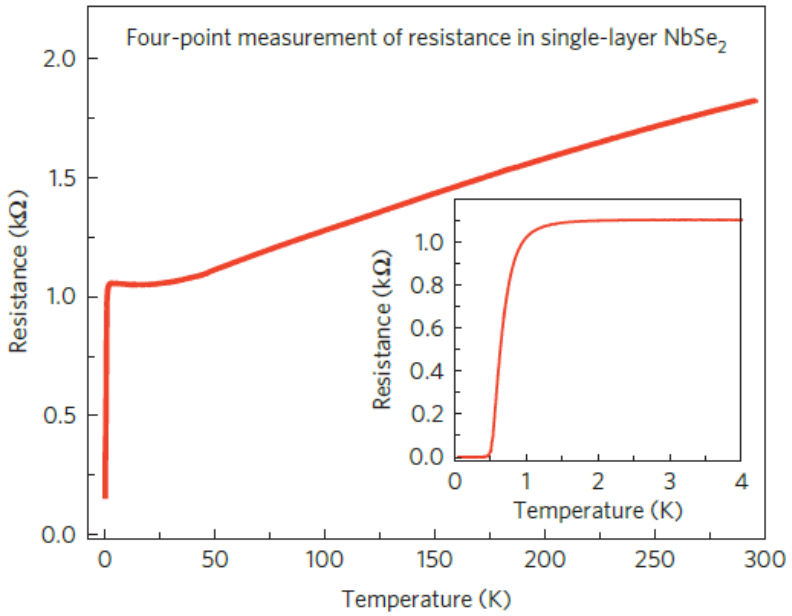

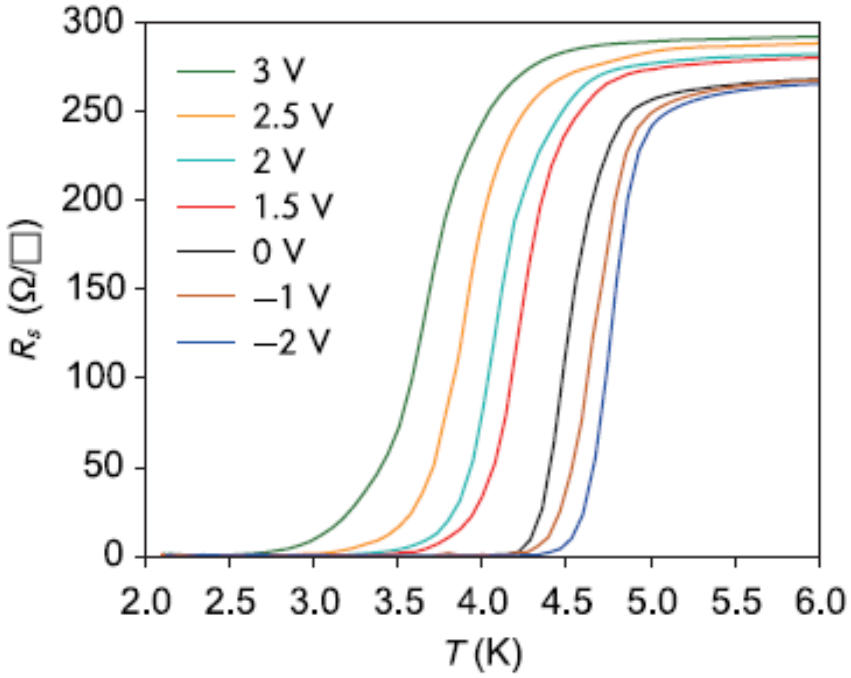

Xi X. et al. , *Phys. Rev. Lett.***117**, 106801 (2016)

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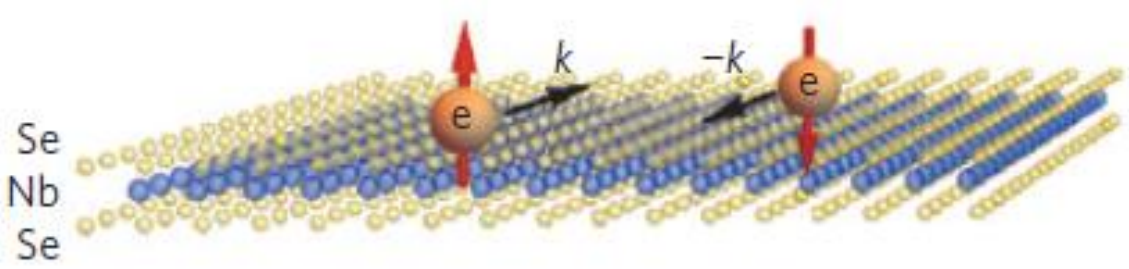
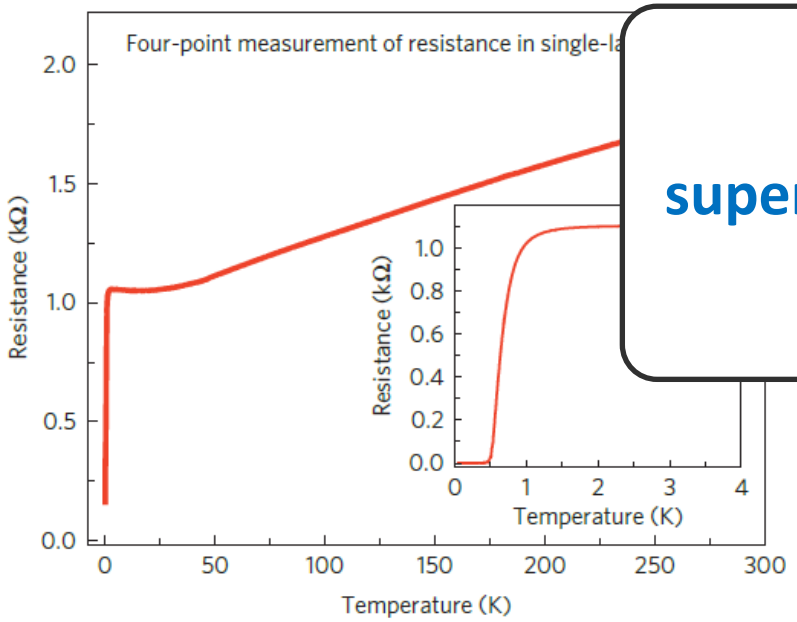
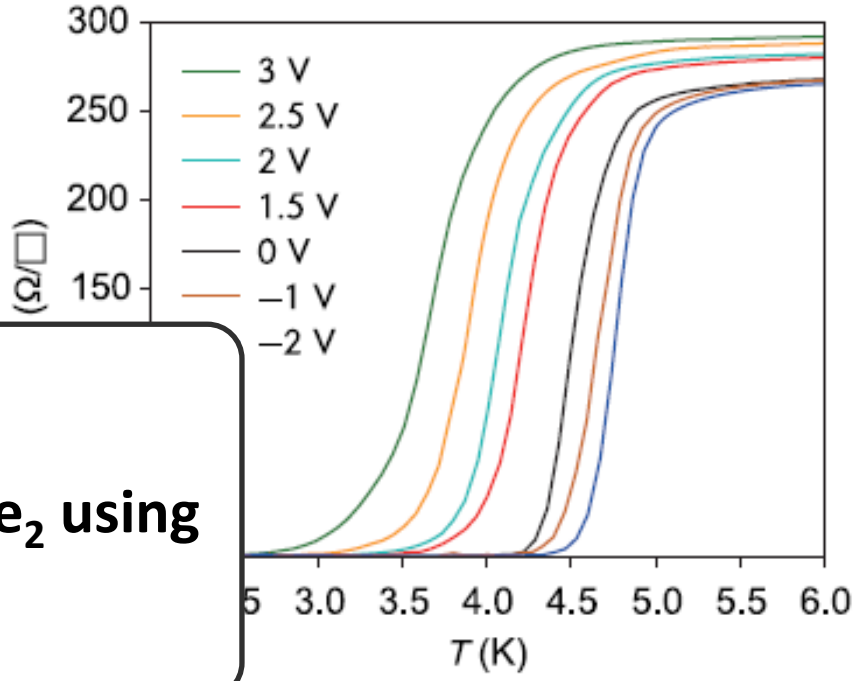




Can we tailor the superconductivity in $NbSe_2$ using molecules?



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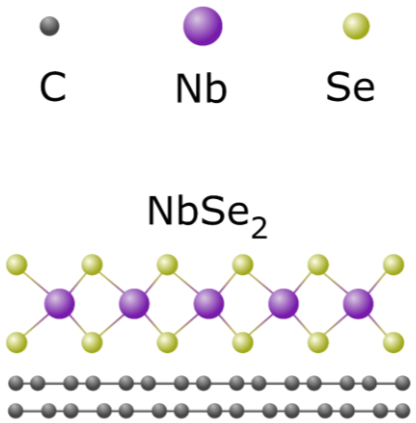
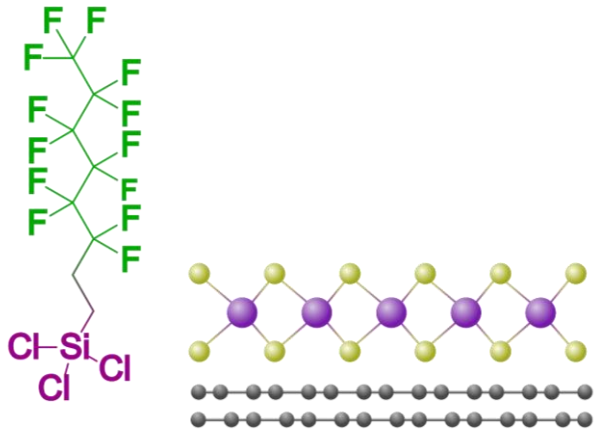
Tailoring superconductivity in large-area $NbSe_2$

Self-assembled adlayers on $NbSe_2$

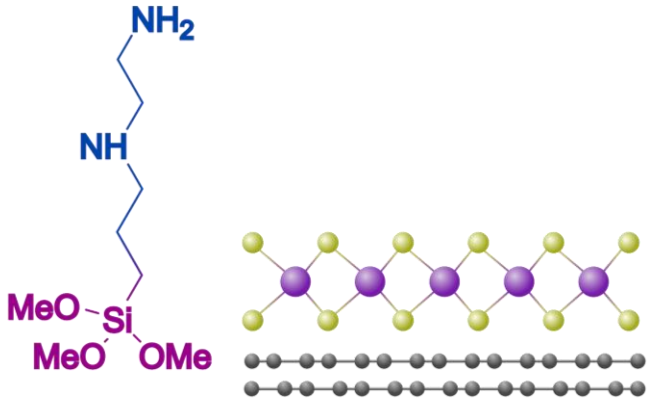
pristine



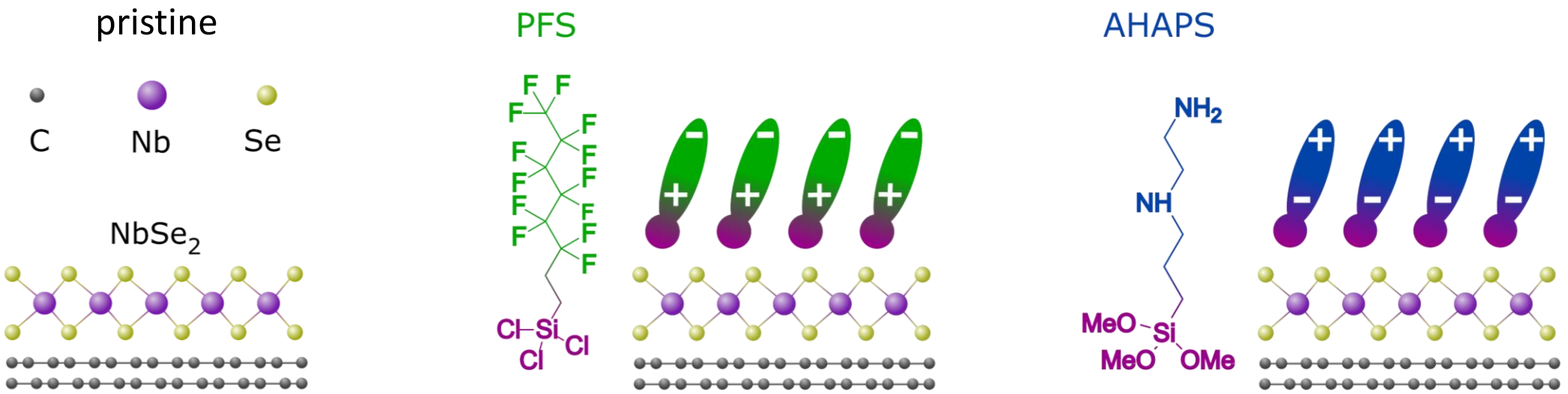
PFS



AHAPS

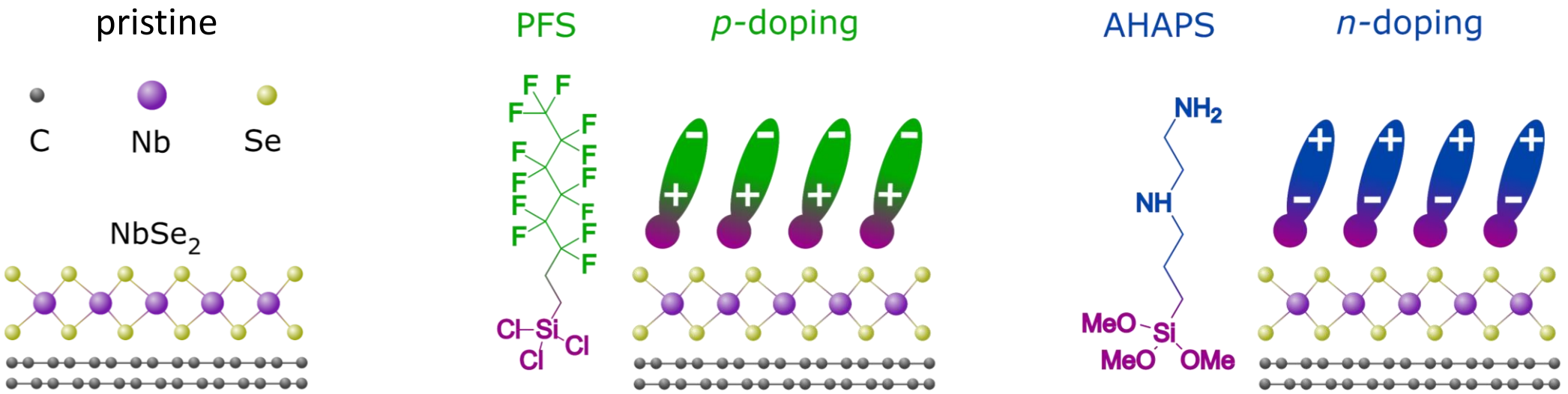


Self-assembled adlayers on $NbSe_2$



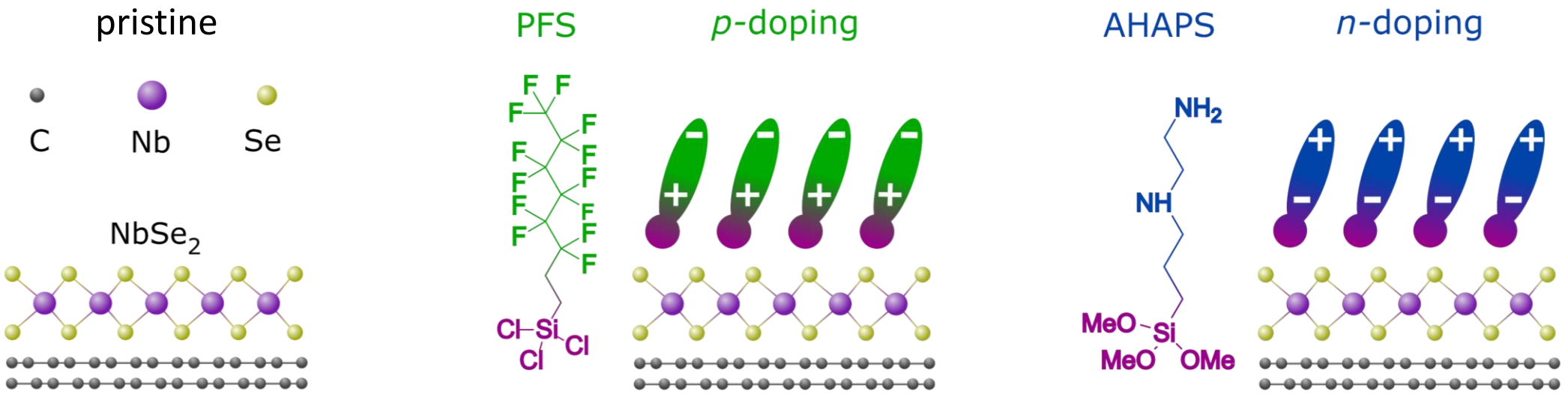
1. Verify whether molecules form ordered layers

Self-assembled adlayers on $NbSe_2$



2. Verify whether self-assembled adlayers introduces doping

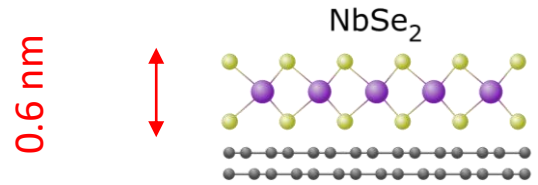
Self-assembled adlayers on $NbSe_2$

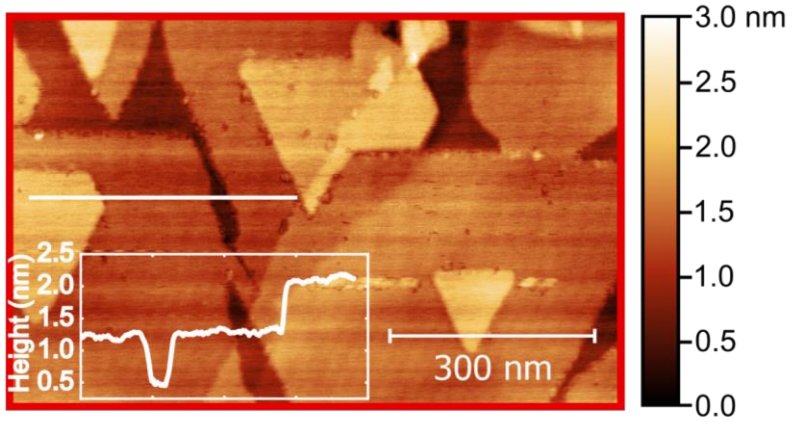


3. Effect of molecules on superconductivity

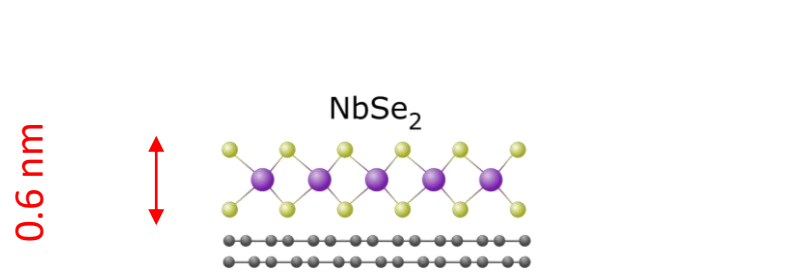
Molecular Adlayers on $NbSe_2$: morphology

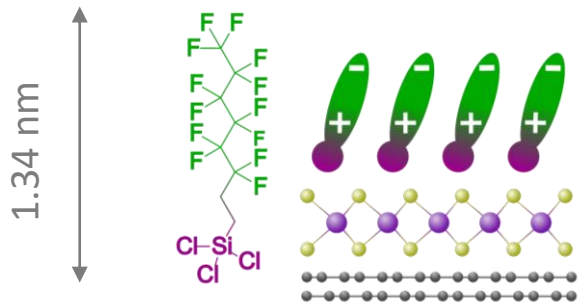
Large area $NbSe_2$ grown by molecular beam epitaxy

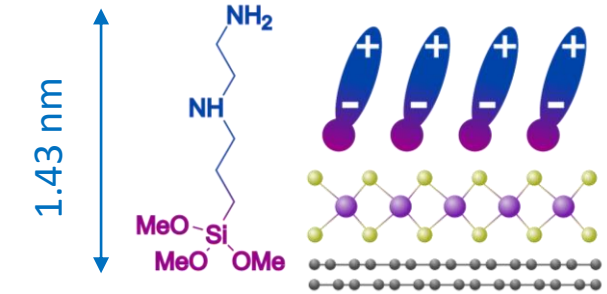


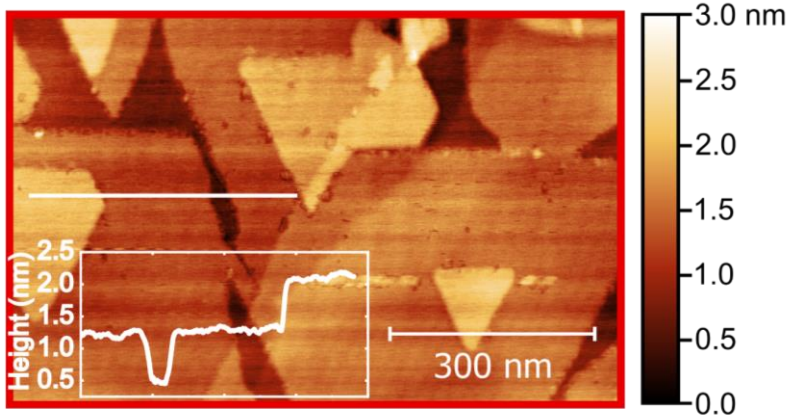


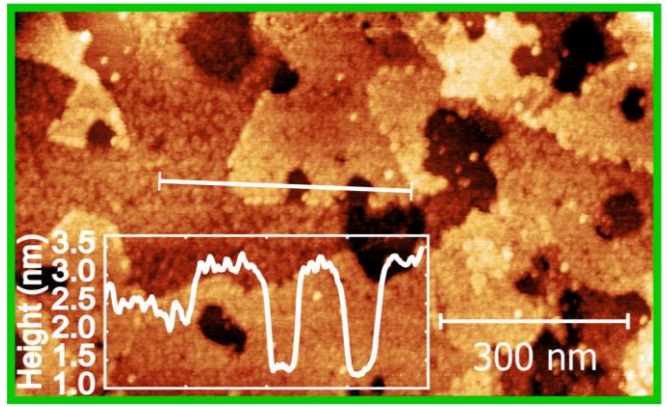
Molecular Adlayers on $NbSe_2$: morphology

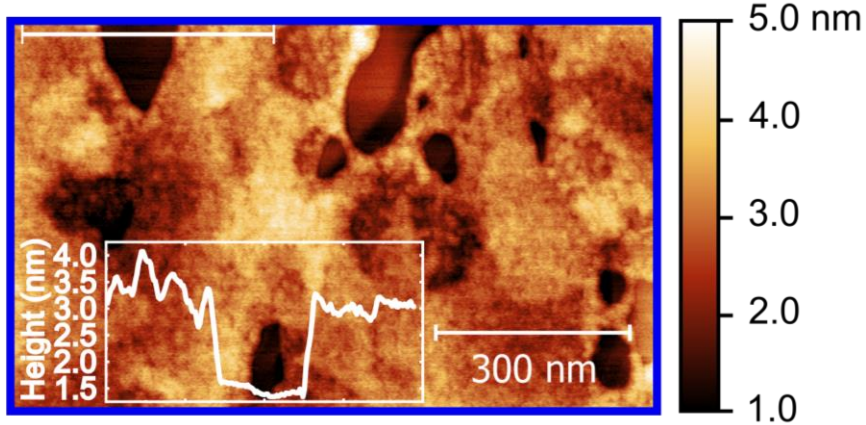




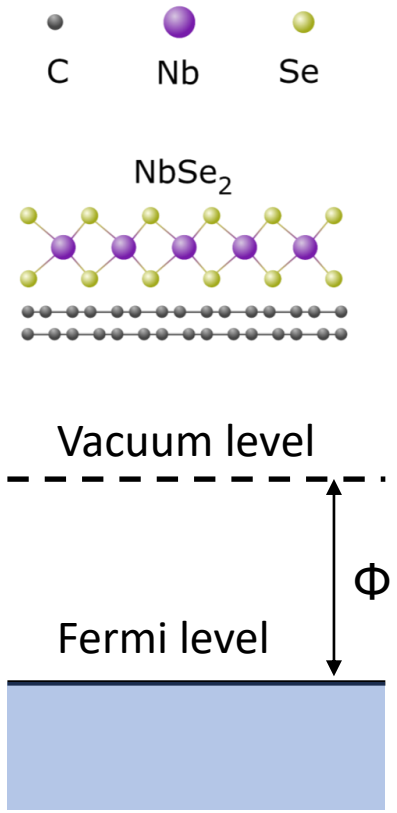




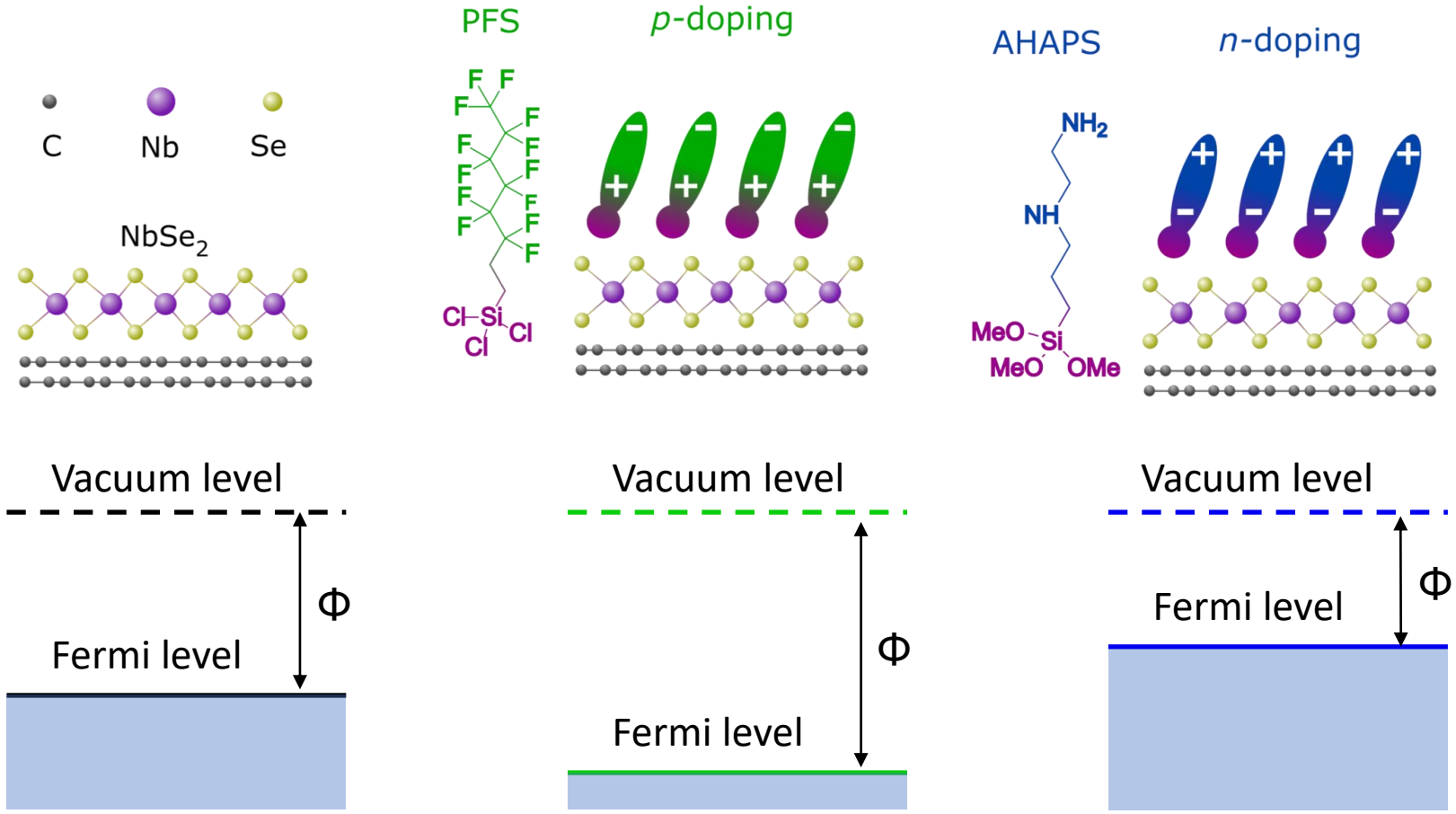




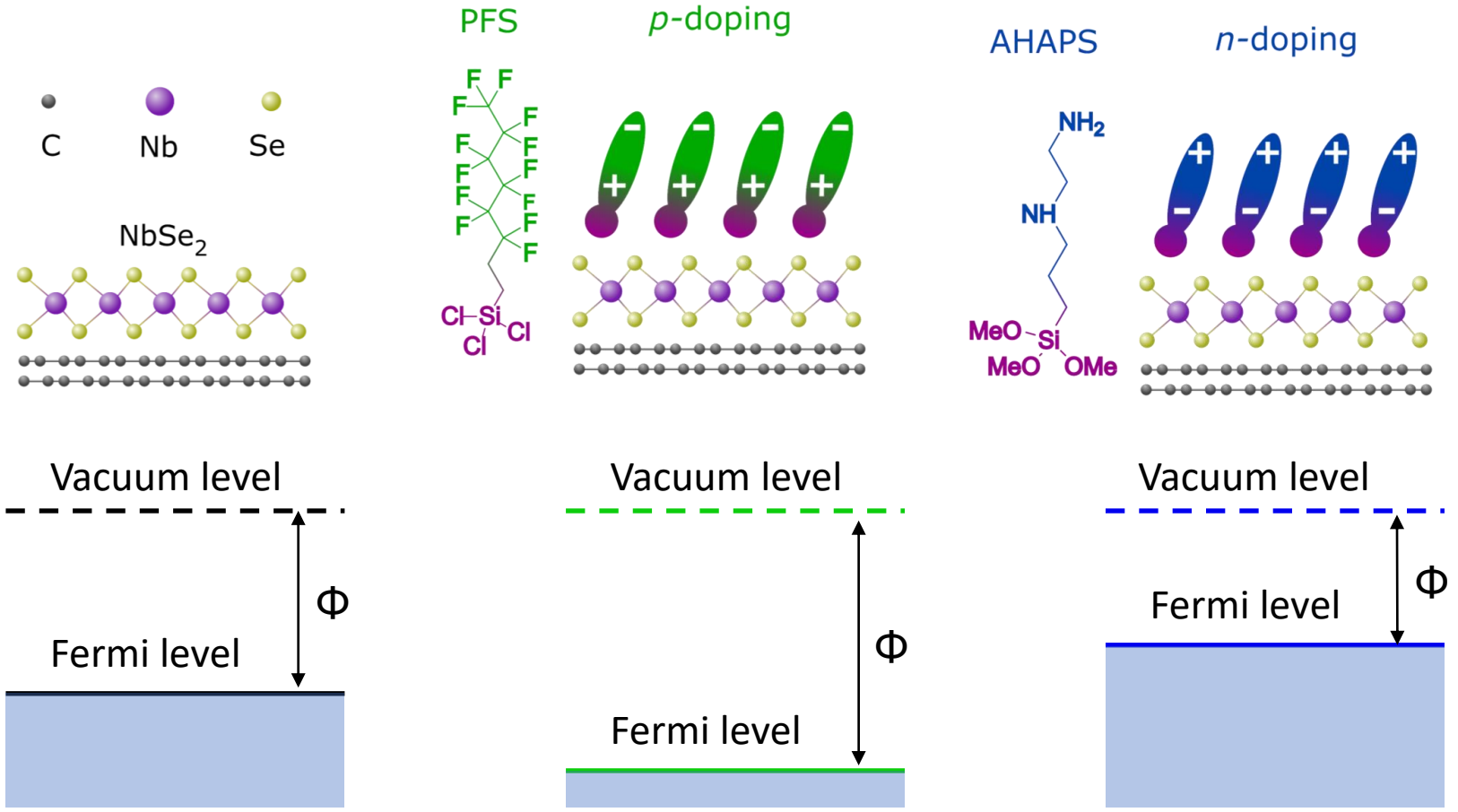
Molecular Adlayers on $NbSe_2$: work function

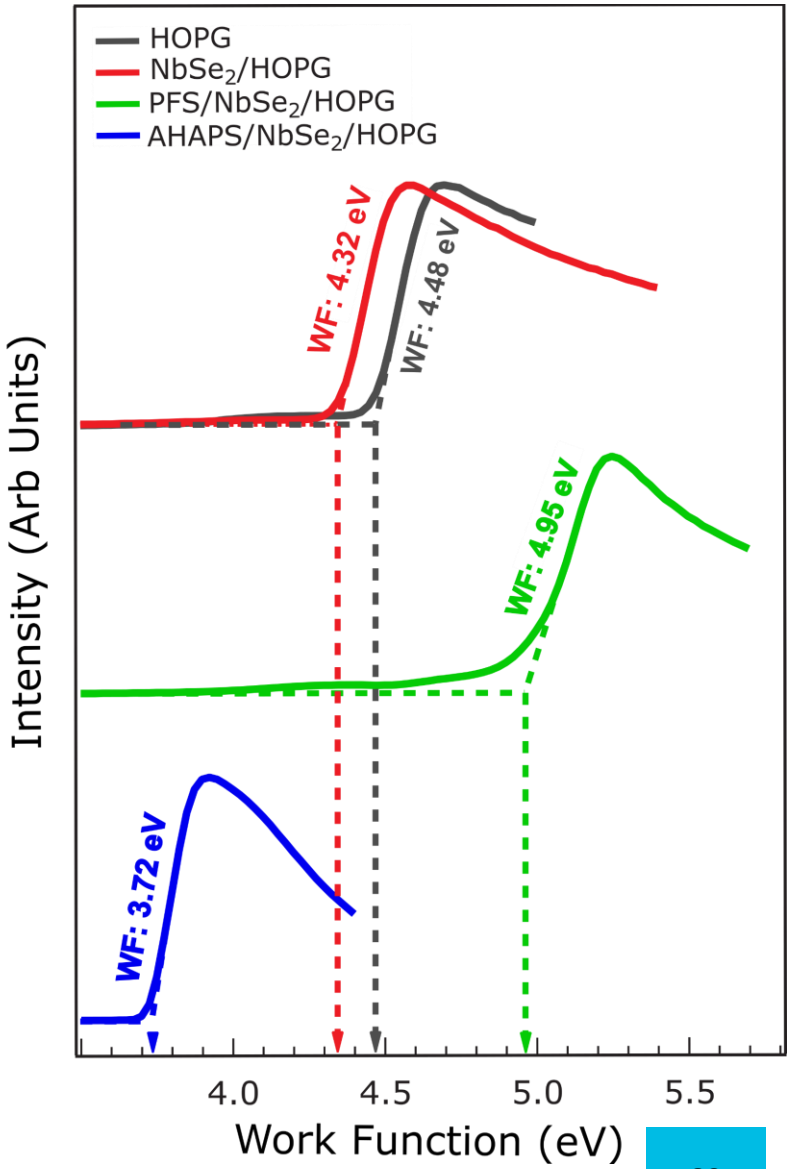


Molecular Adlayers on $NbSe_2$: work function

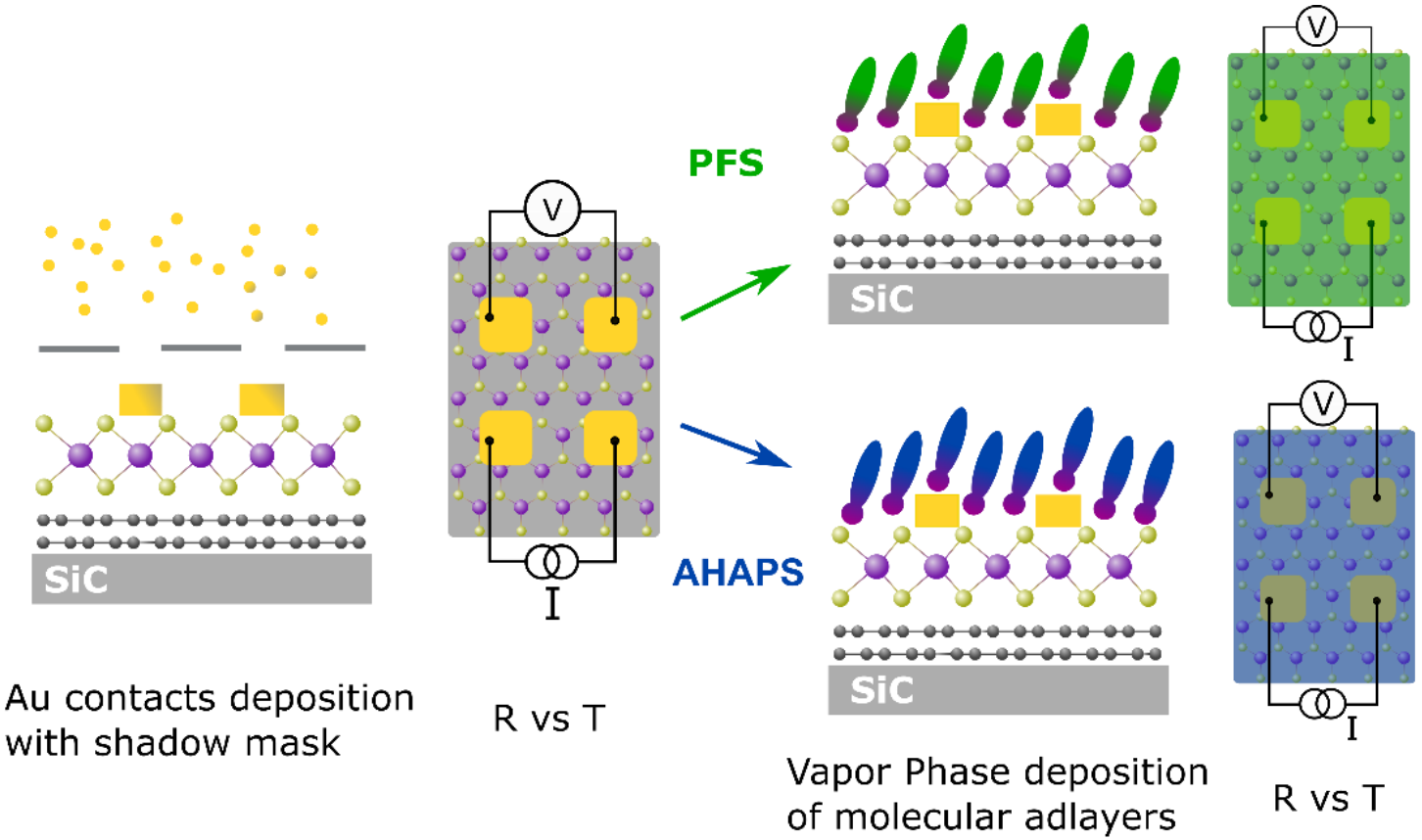


Molecular Adlayers on $NbSe_2$: work function





Adlayers on $NbSe_2$: superconductivity



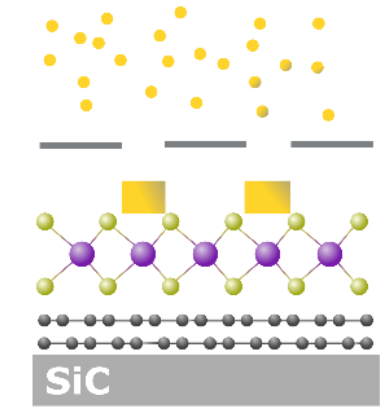
Au contacts deposition with shadow mask

R vs T

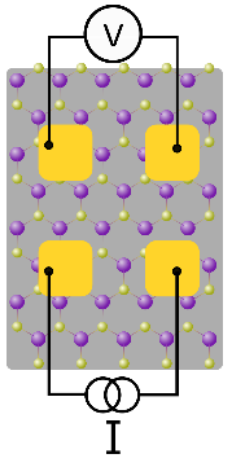
Vapor Phase deposition of molecular adlayers

R vs T

Adlayers on $NbSe_2$: superconductivity



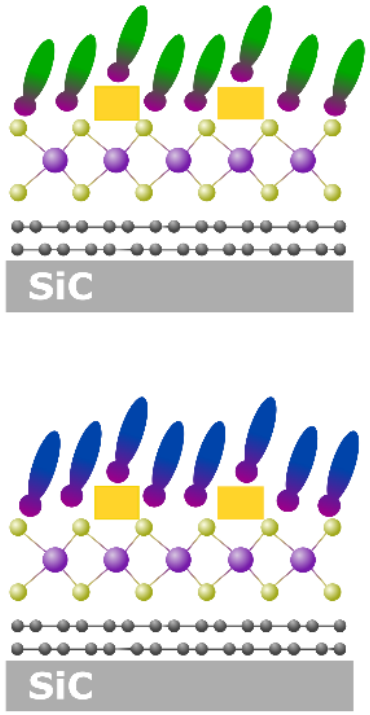
Au contacts deposition with shadow mask



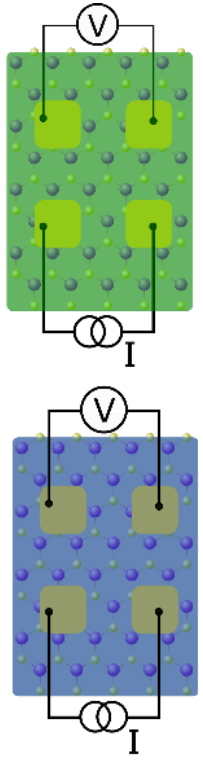
R vs T

PFS

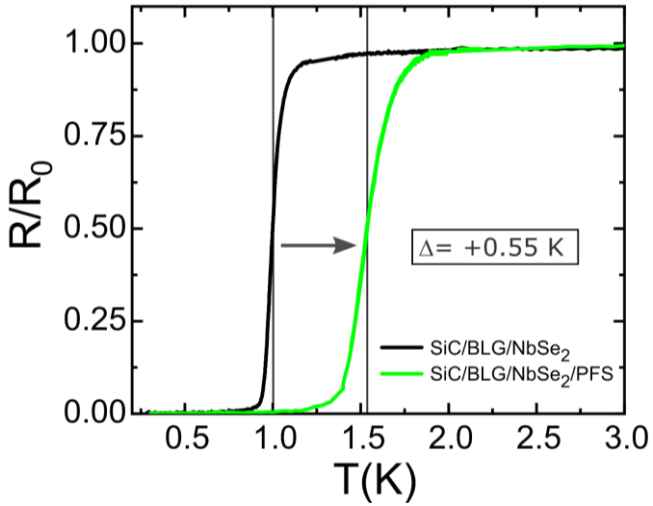
AHAPS

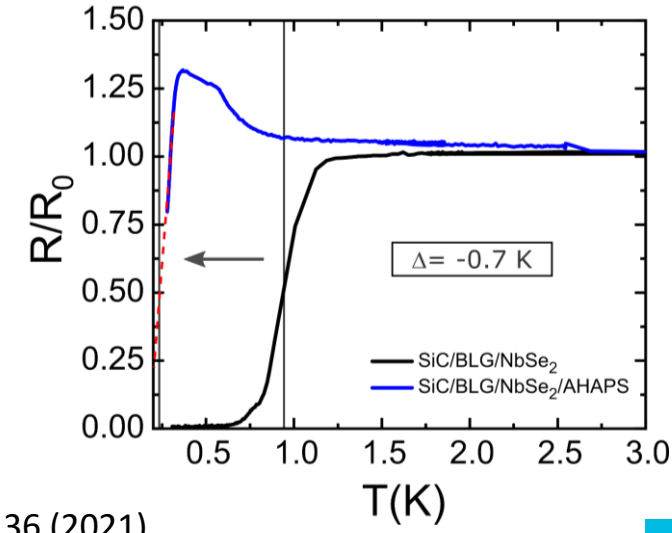


Vapor Phase deposition of molecular adlayers



R vs T





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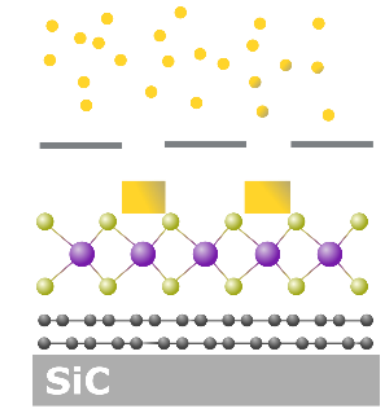
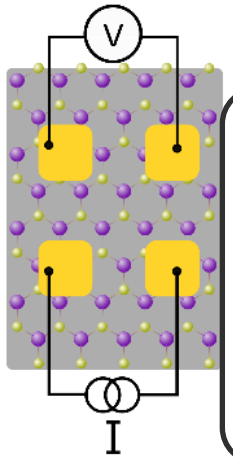
Adlayers on $NbSe_2$: superconductivity

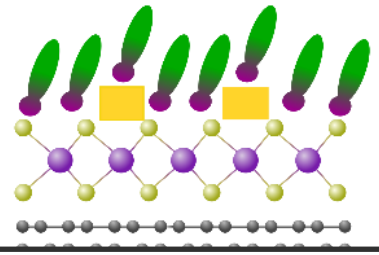


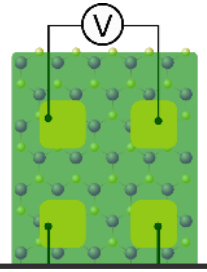
Au contacts deposition with shadow mask



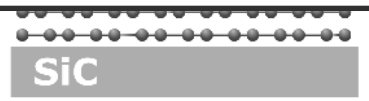
R vs T

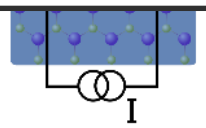
PFS





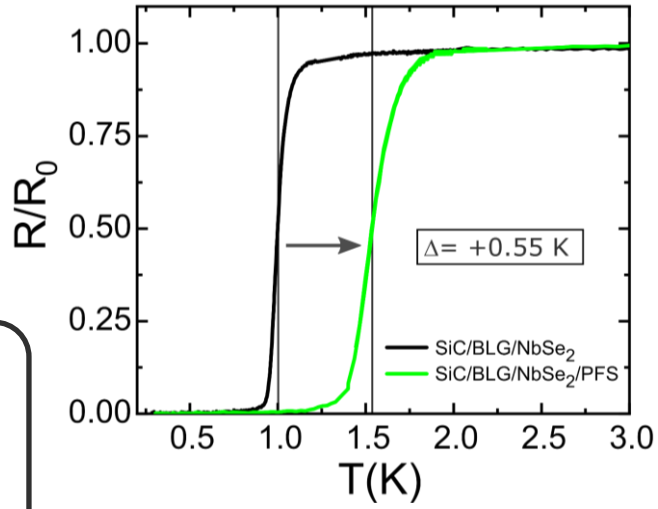
Self-assembled adlayers enable tuning T_C

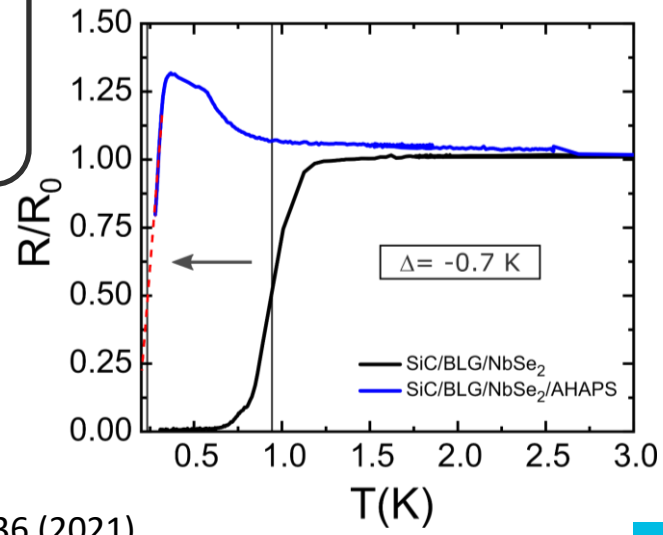




Vapor Phase deposition of molecular adlayers

R vs T





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Conclusions and perspectives

- ✓ Organosilanes form ordered self-assembled adlayers on $NbSe_2$
- ✓ The self-assembled adlayers act as a fixed gate electrode
- ✓ Molecular functionalization enable a predictable tuning of T_C in large-area $NbSe_2$

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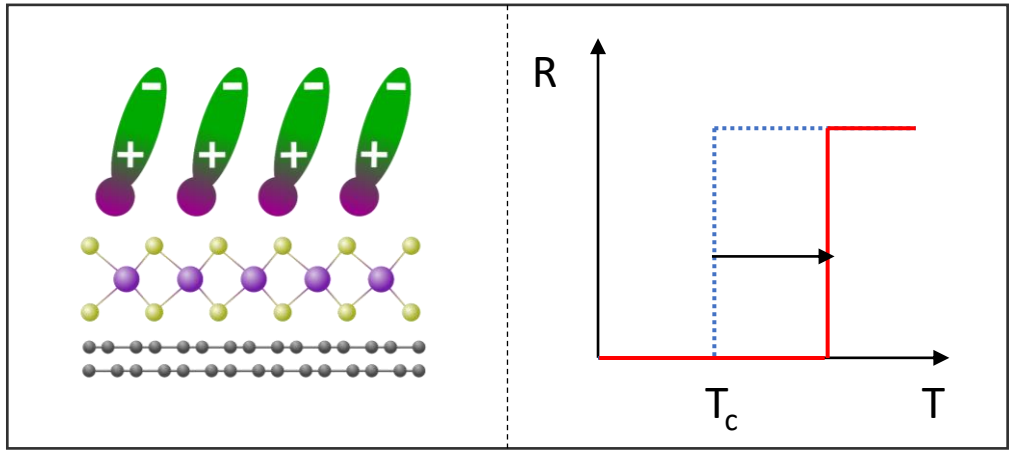
- Is it possible to introduce superconductivity in non superconductive 2D materials?
- Can we manipulate other intrinsic properties of 2DMs using molecules (magnetism)?

ePoster 47 by Daniel Tezze



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