

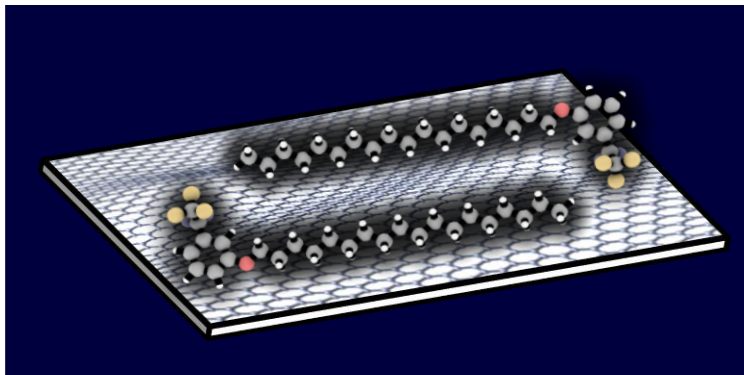


7th edition of the largest European Conference & Exhibition in Graphene and 2D Materials

Optically-tunable periodic potentials in hybrid van der Waals heterostructures

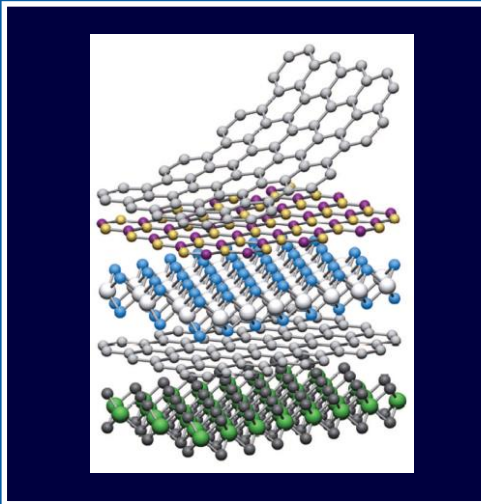
Marco Gobbi

S. Bonacchi, J. Lian, Y. Liu, X.-Y. Wang, M.-A. Stoeckel, M. A. Squillaci, G. D'Avino, A. Narita, K. Müllen, X. Feng, Y. Olivier, D. Beljonne, P. Samorì, E. Orgiu



Nanochemistry Laboratory
Institut de Science et d'Ingénierie Supramoléculaires (**ISIS**)
Université de Strasbourg (FRANCE)

Outline

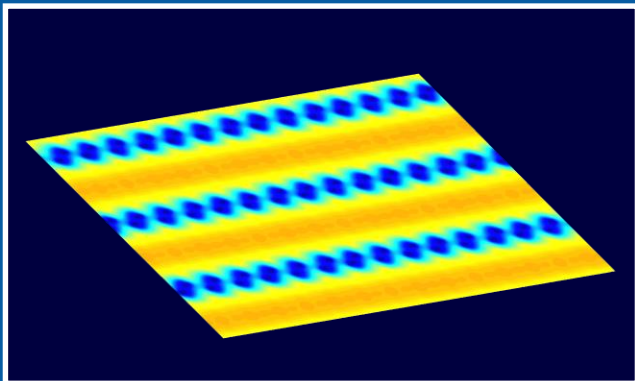
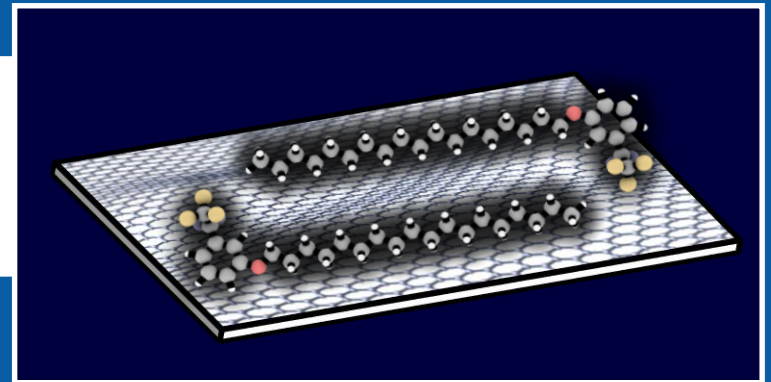


I- Introduction

- *van der Waals heterostructures*
- *Periodic potentials*

2- 2D materials and molecules

- *Molecular monolayers*
- *Atomic control of assembly*

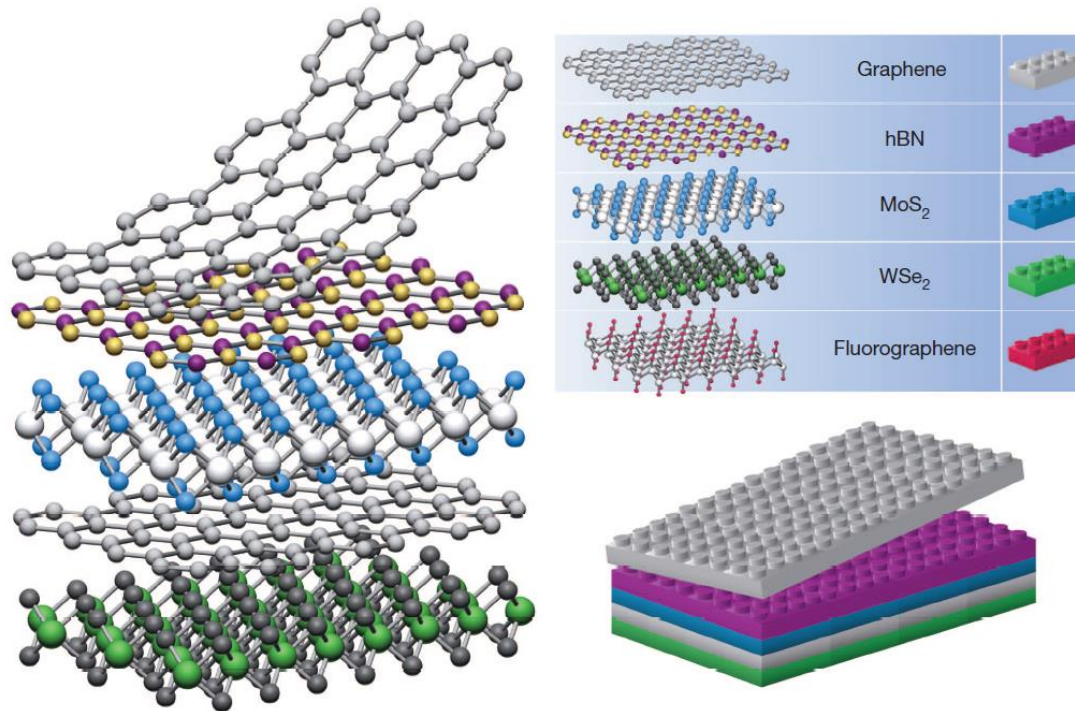


3- Hybrid van der Waals heterostructures

Tunable periodic potentials

Conclusions

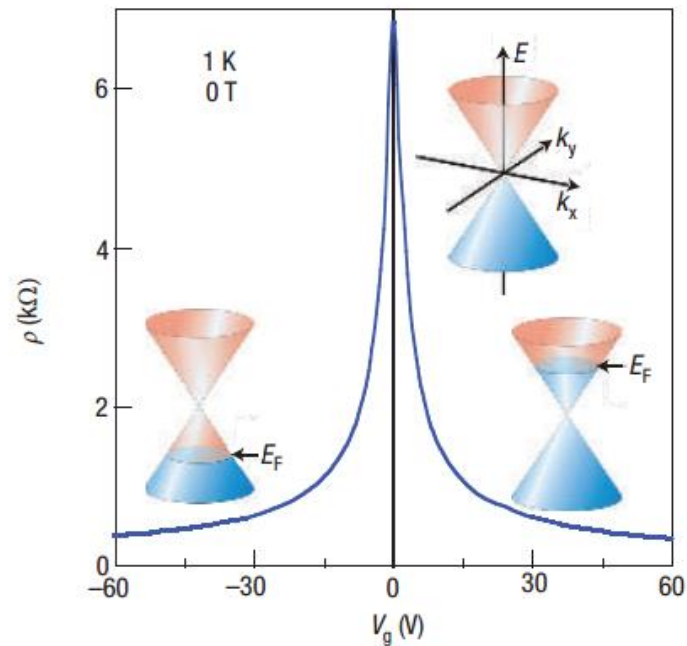
Electrical, optical and magnetic properties are tunable



A. K. Geim, I.V. Grigorieva. *Nature* (2013)

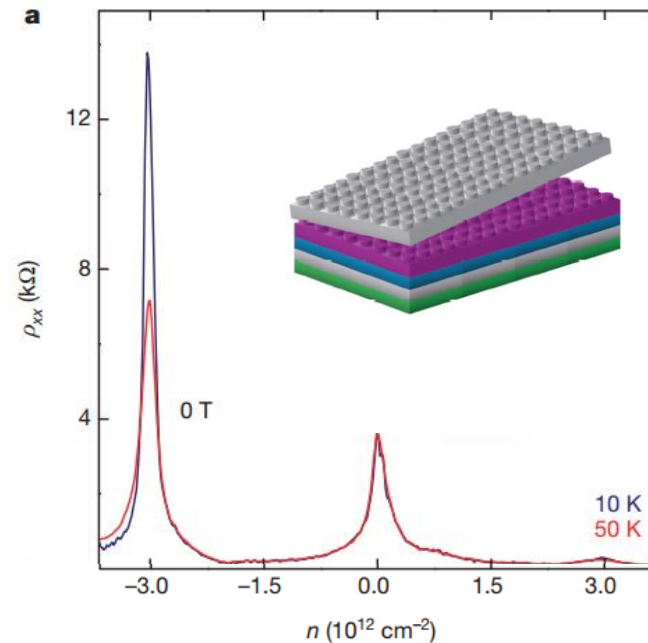
Modification of the electronic properties of graphene

Graphene on SiO₂



A. K. Geim and K. S. Novoselov, *Nature Materials*, (2007)

Graphene on hBN



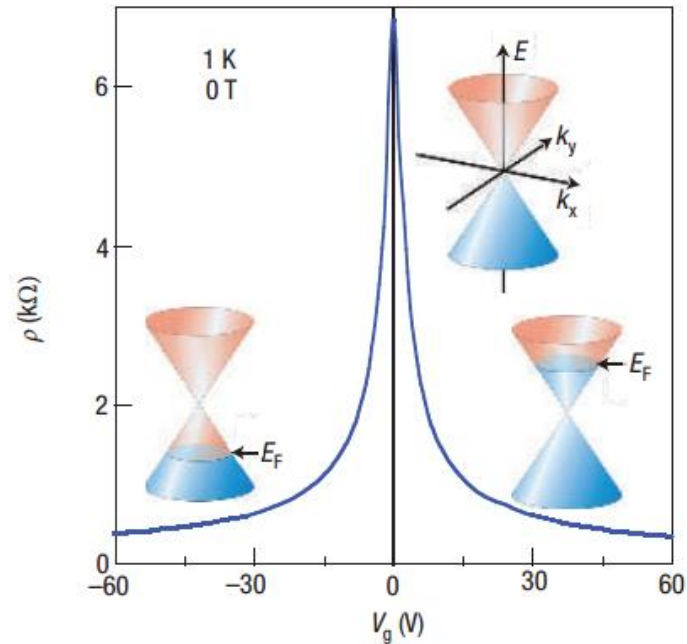
L. A. Ponomarenko *et al.*, *Nature* 2013

C. R. Dean *et al.*, *Nature* 2013

B. Hunt *et al.* *Science* 2013

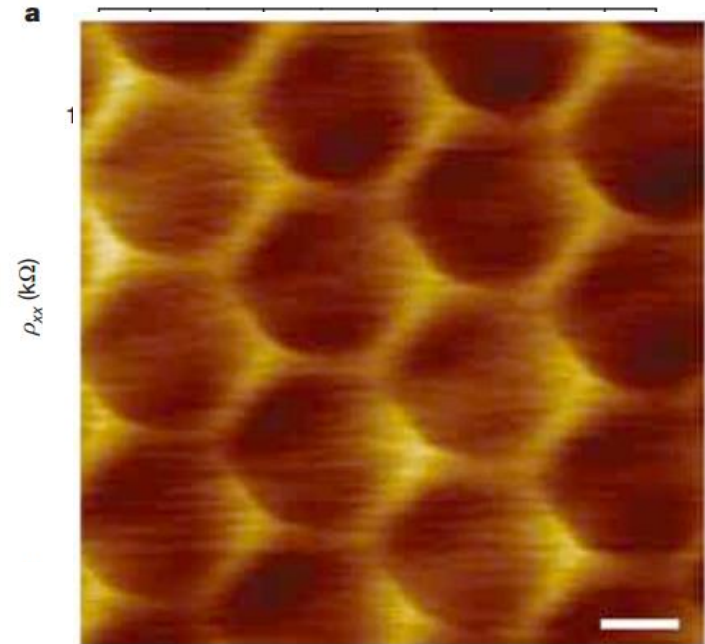
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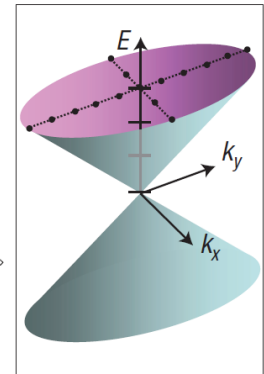
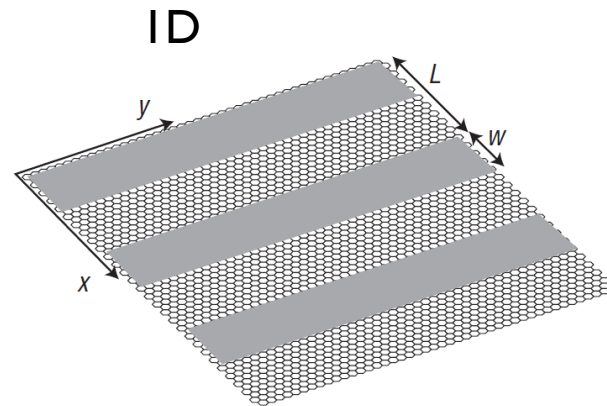
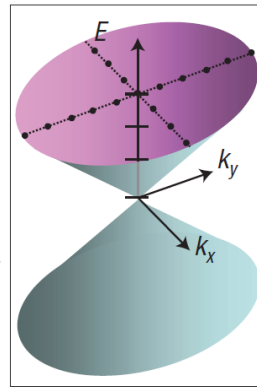
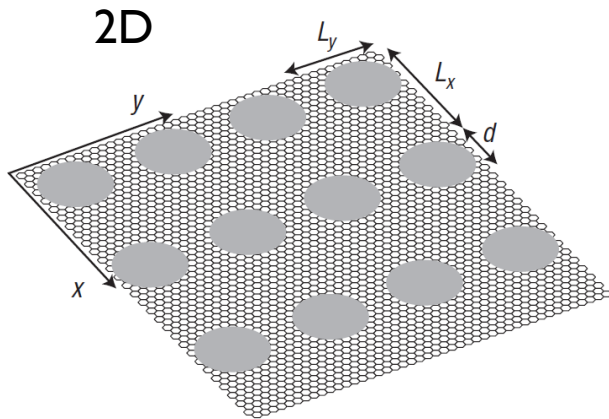
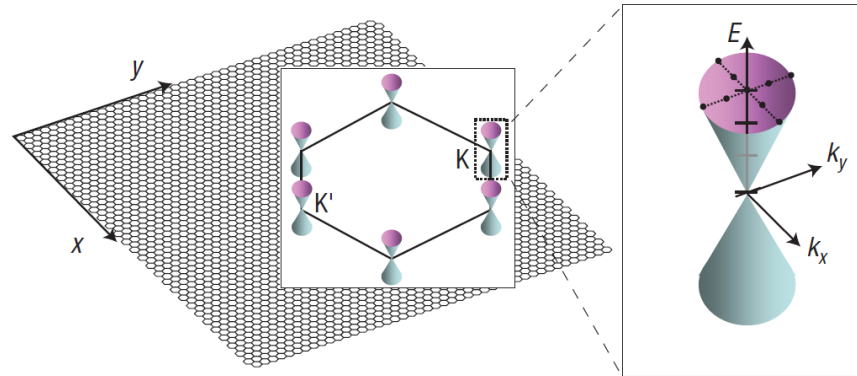
A. K. Geim and K. S. Novoselov, *Nature Materials*, (2007)

Graphene on hBN



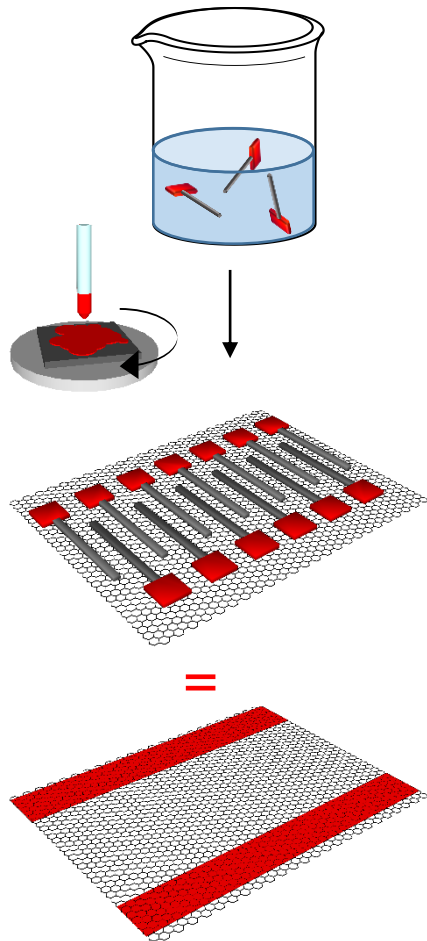
Yankowitz, *Nat. Phys.* (2012)

Van der Waals heterostructures. Periodic potentials

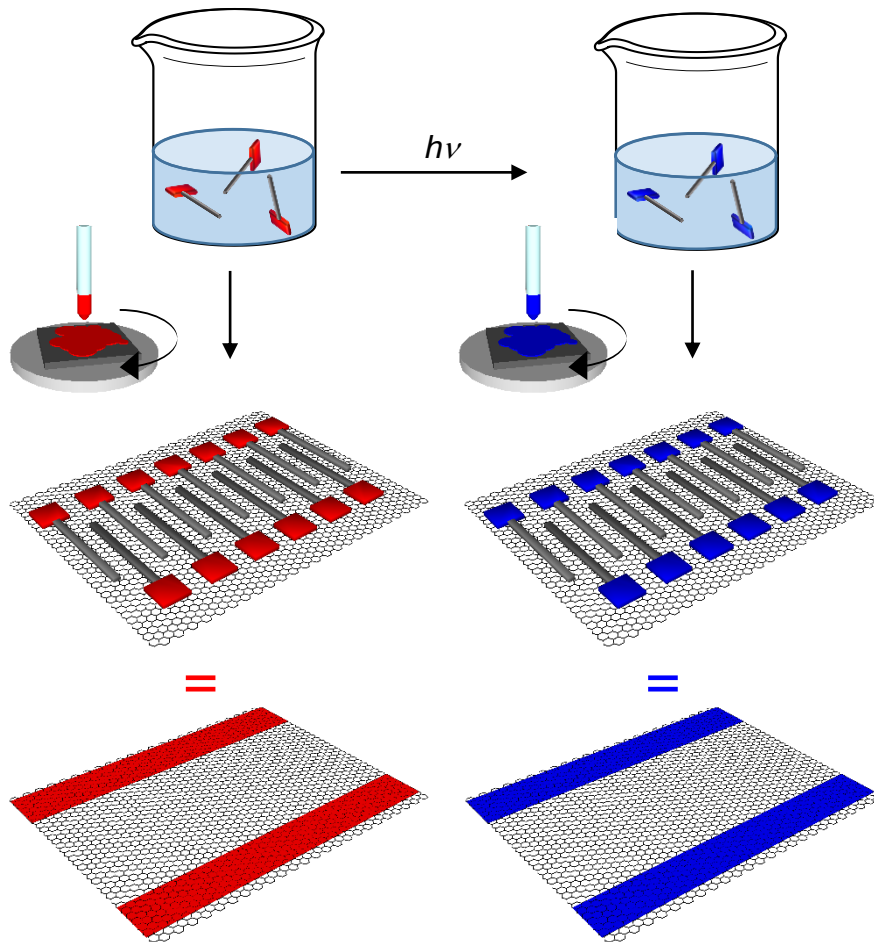


C. H. Park et al. *Nature Physics*, (2008)

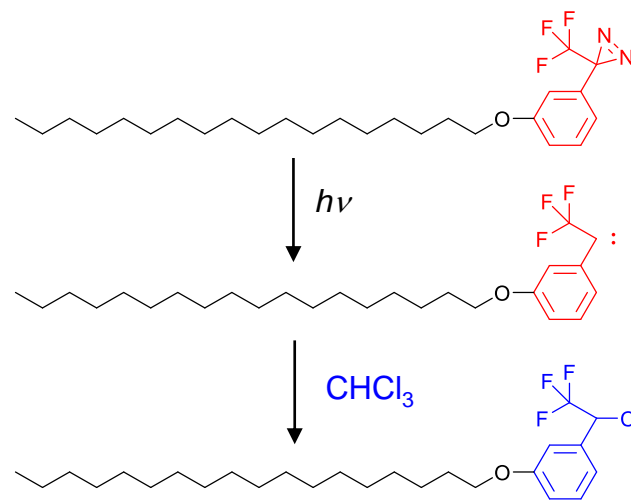
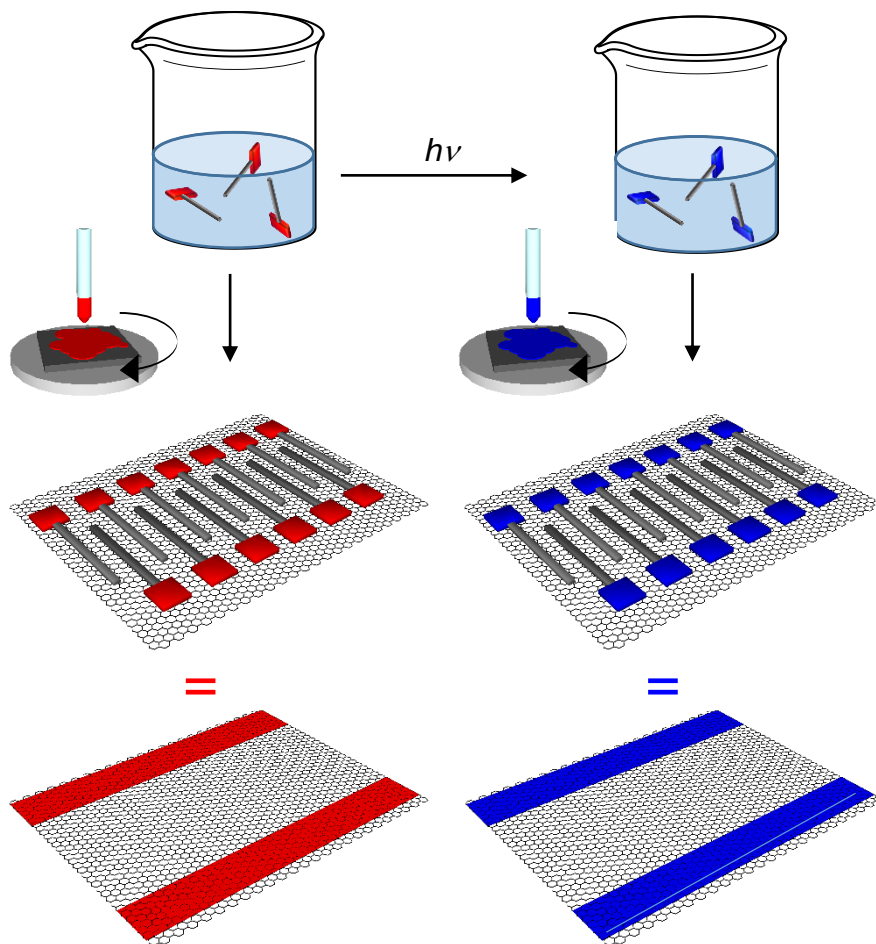
Periodic potentials. Our approach



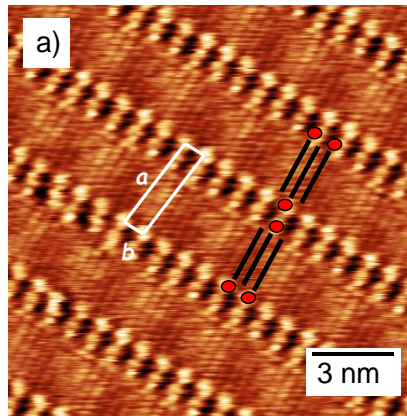
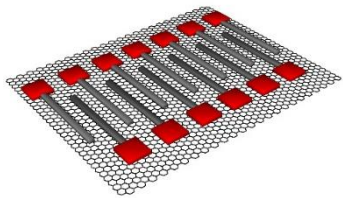
Periodic potentials. Our approach



Periodic potentials. Our approach



M. Gobbi et al. *Nature Commun.*, 8:14767 (2017)



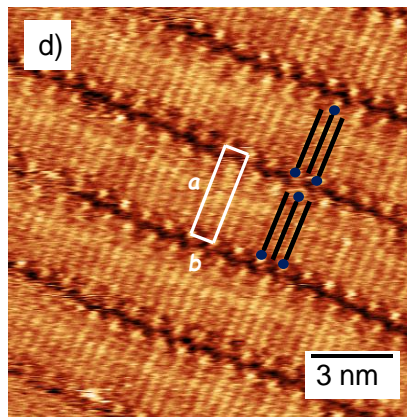
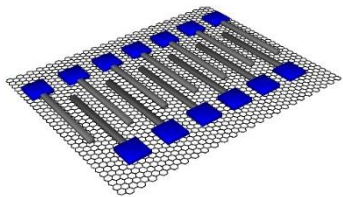
Unit cells:

$$a = (3.8 \pm 0.2) \text{ nm}$$

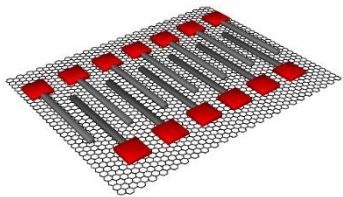
$$b = (0.9 \pm 0.1) \text{ nm}$$

$$A = (3.4 \pm 0.2) \text{ nm}^2$$

$$\alpha = (84 \pm 2)^\circ$$



Periodic potentials. Nanoscale characterization



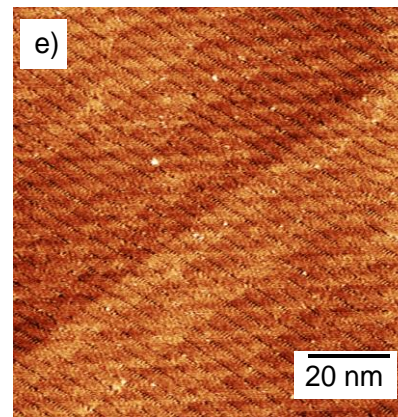
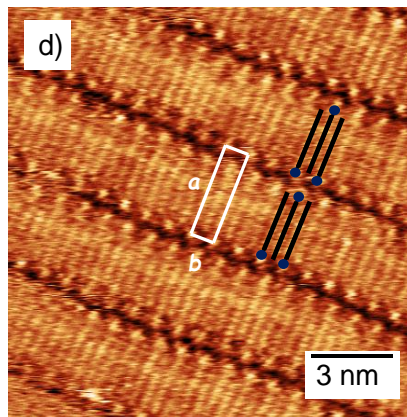
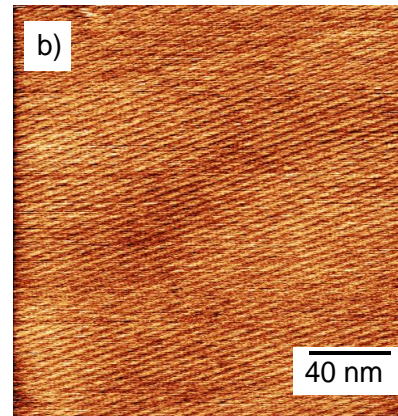
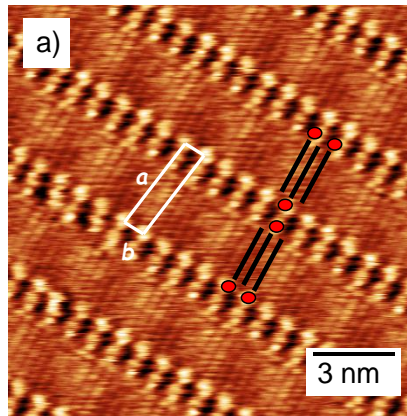
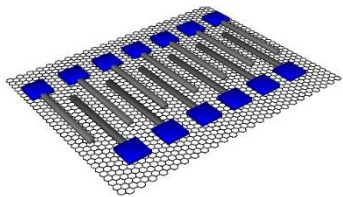
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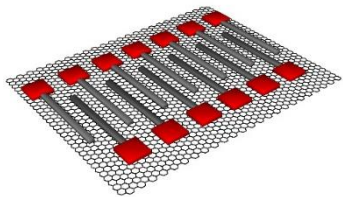
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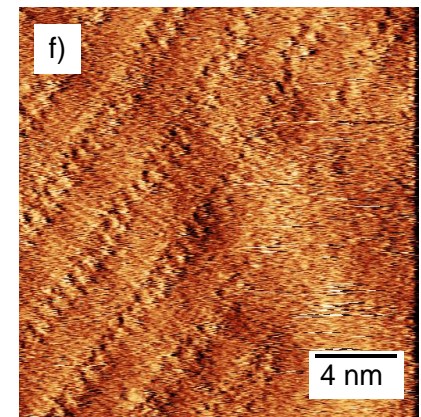
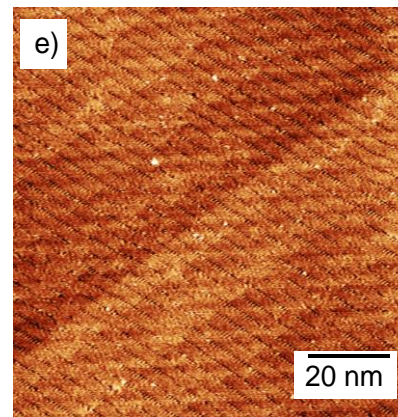
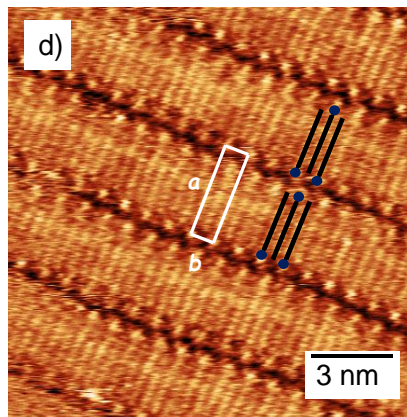
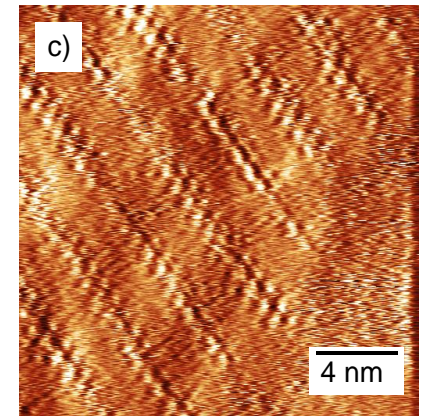
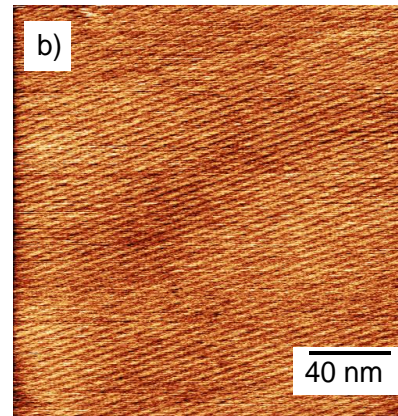
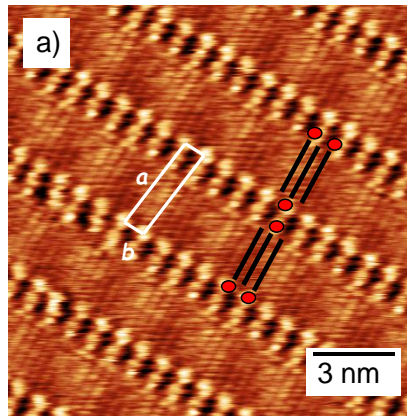
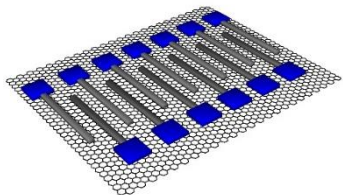
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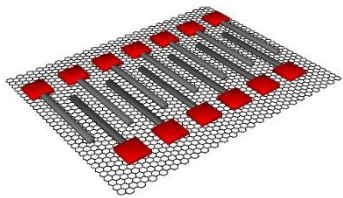
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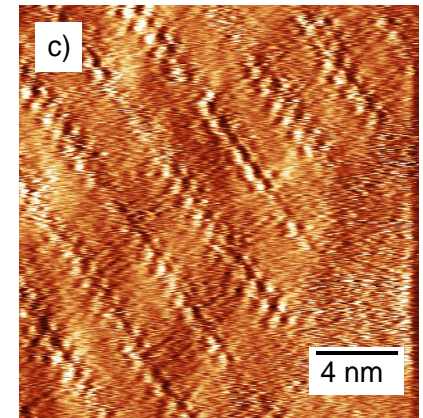
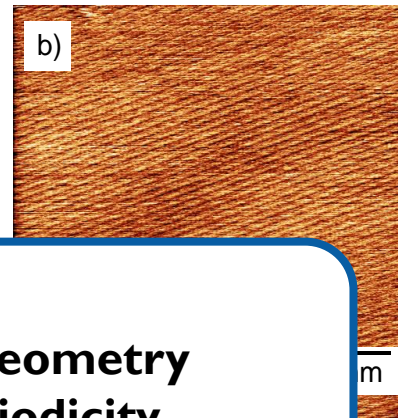
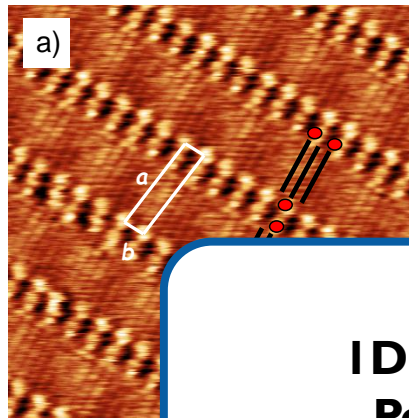
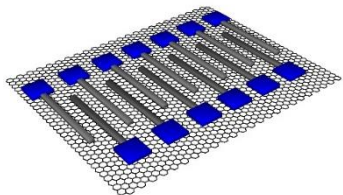
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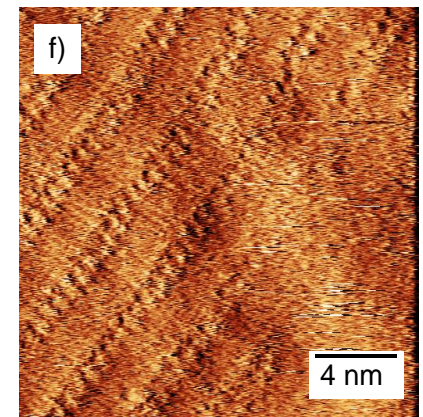
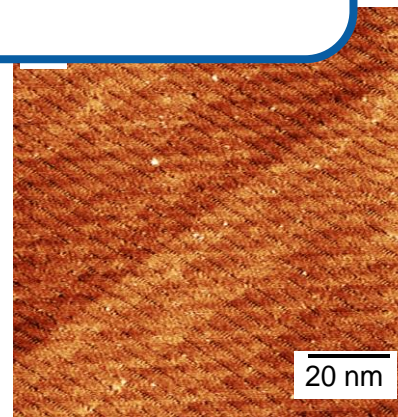
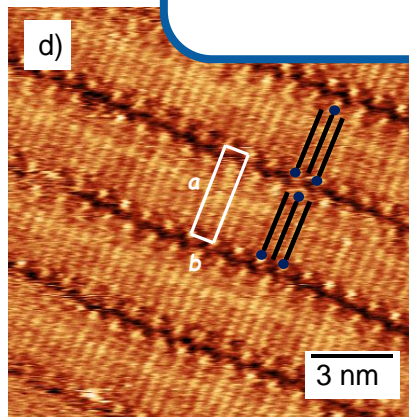




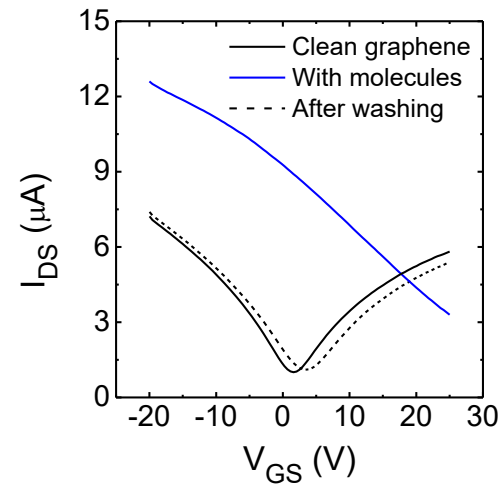
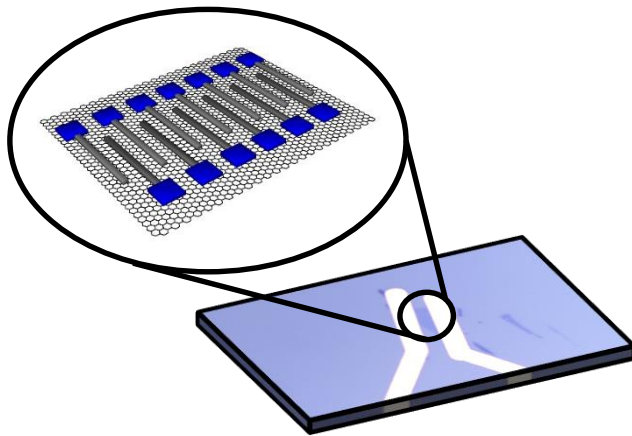
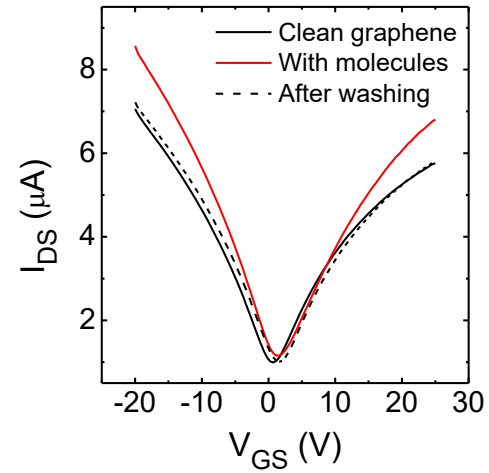
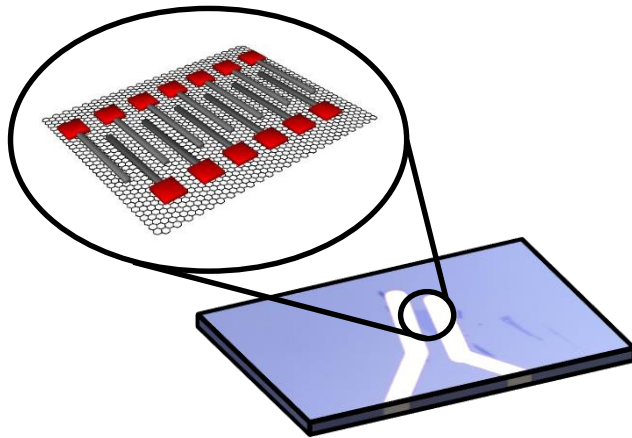
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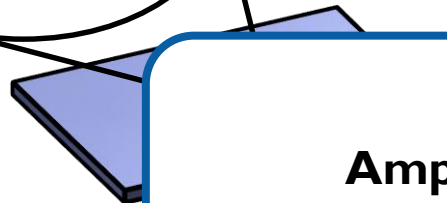
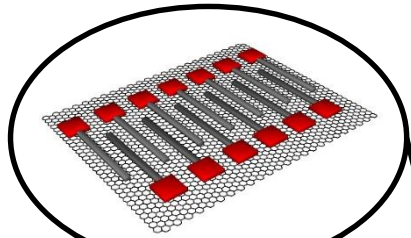


**1D geometry
Periodicity**

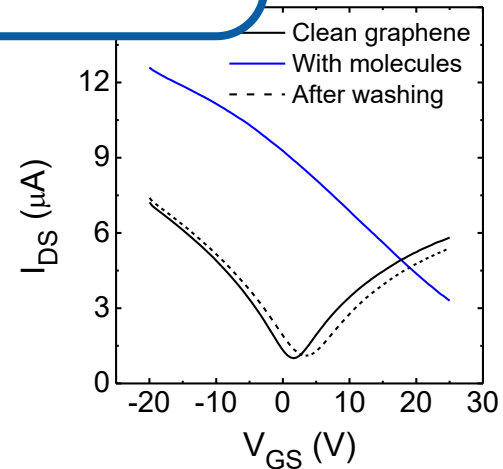
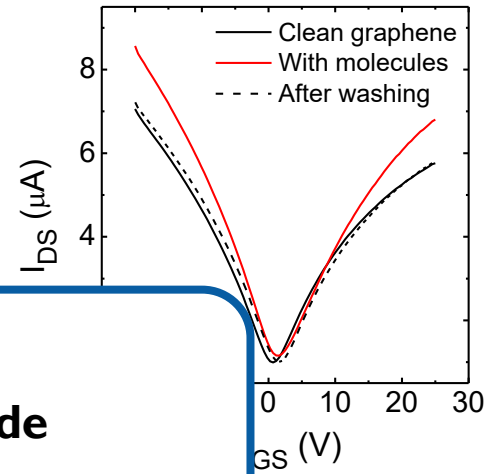
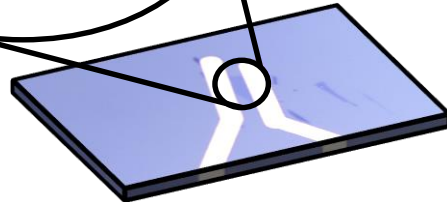
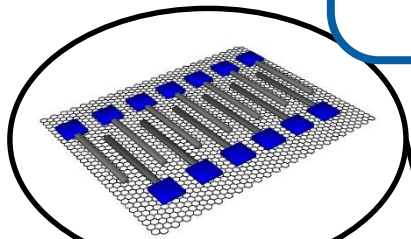


Periodic potentials. Electrical characterization

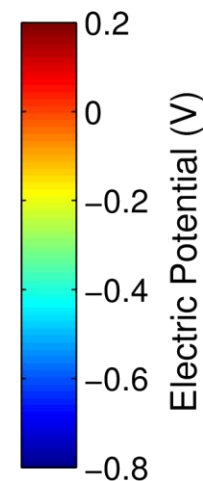
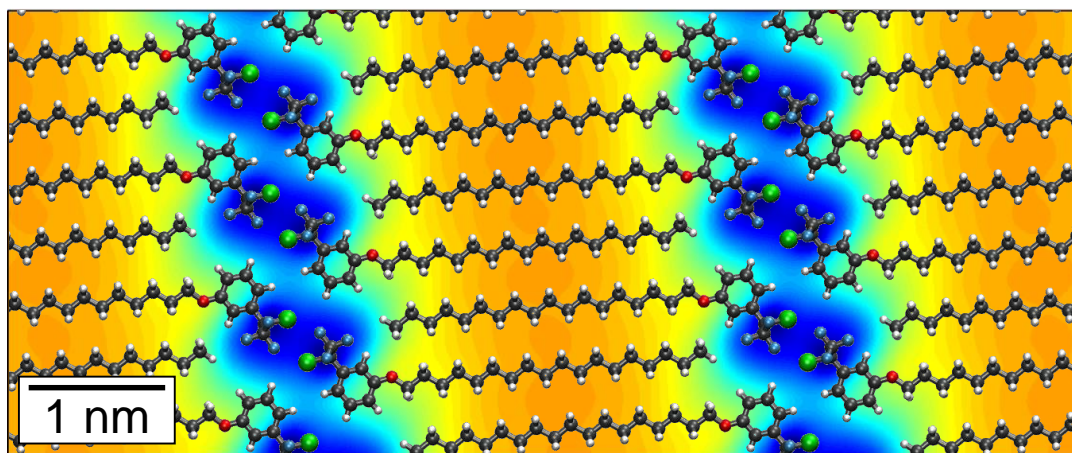
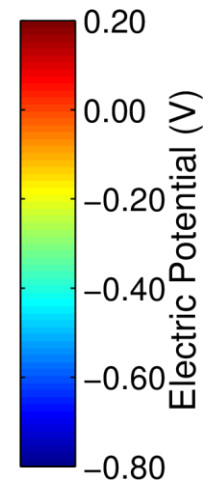
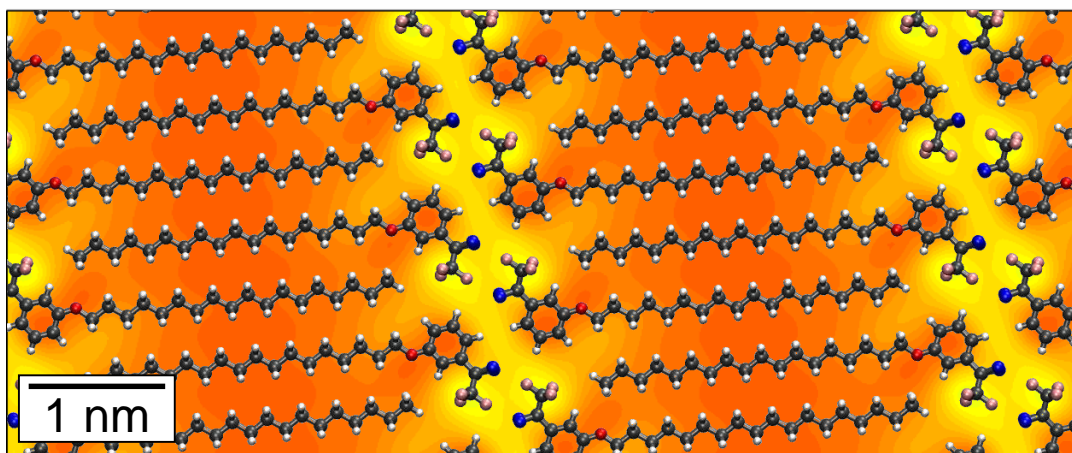




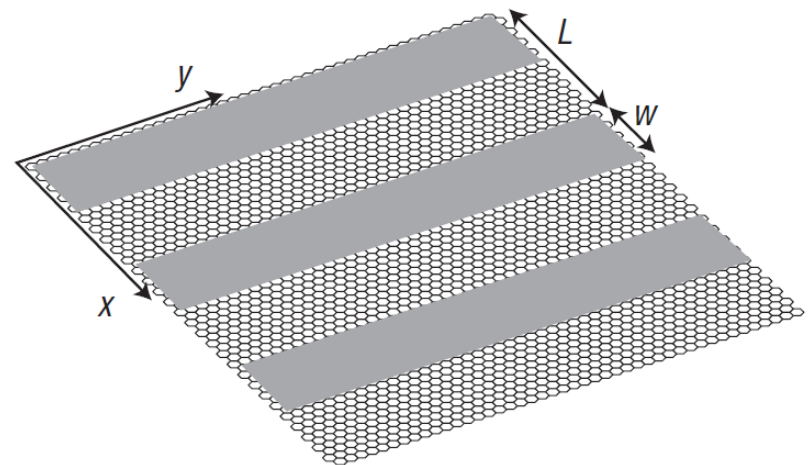
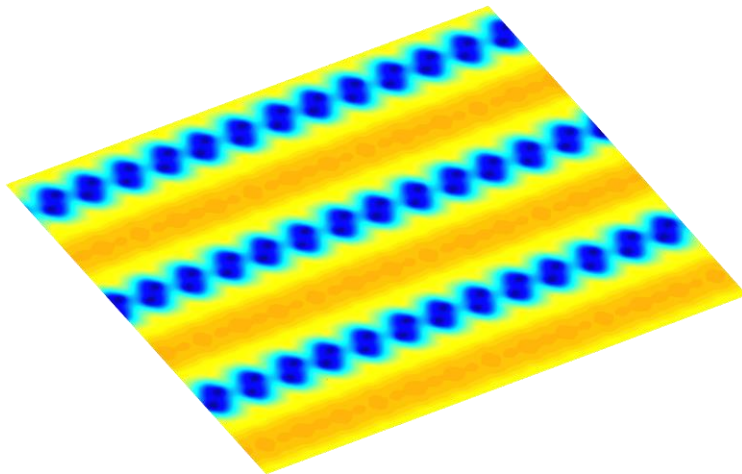
Amplitude



Supramolecular realization of periodic potentials



Chemical approach to van der Waals heterostructures



	Periodicity	Amplitude
Our work	4 nm	0.5V -1V
Prediction*	10 nm	0.5V

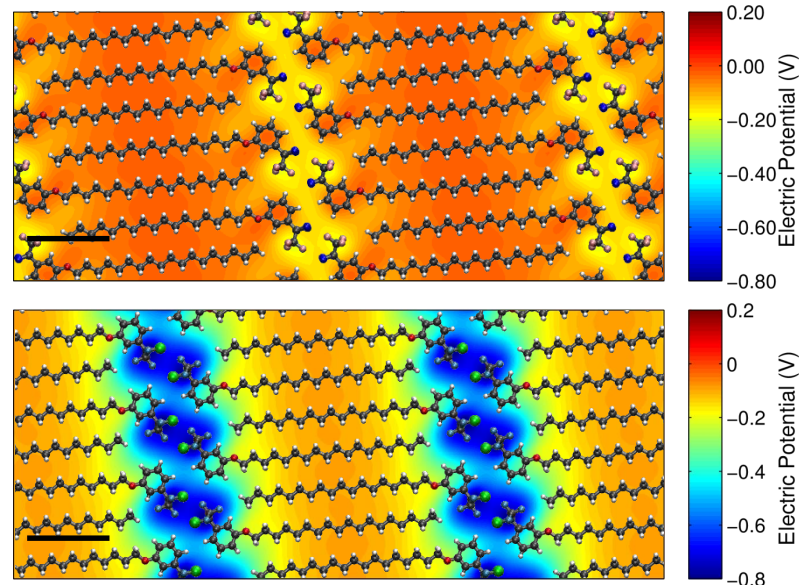
* C. H. Park et al. *Nature Physics*, (2008)

Chemical approach to van der Waals heterostructures

Conclusions:

- ✓ Periodic potentials take place at 2D materials/molecules

- ✓ Programmable
- ✓ Atomically precise
- ✓ Optically tunable

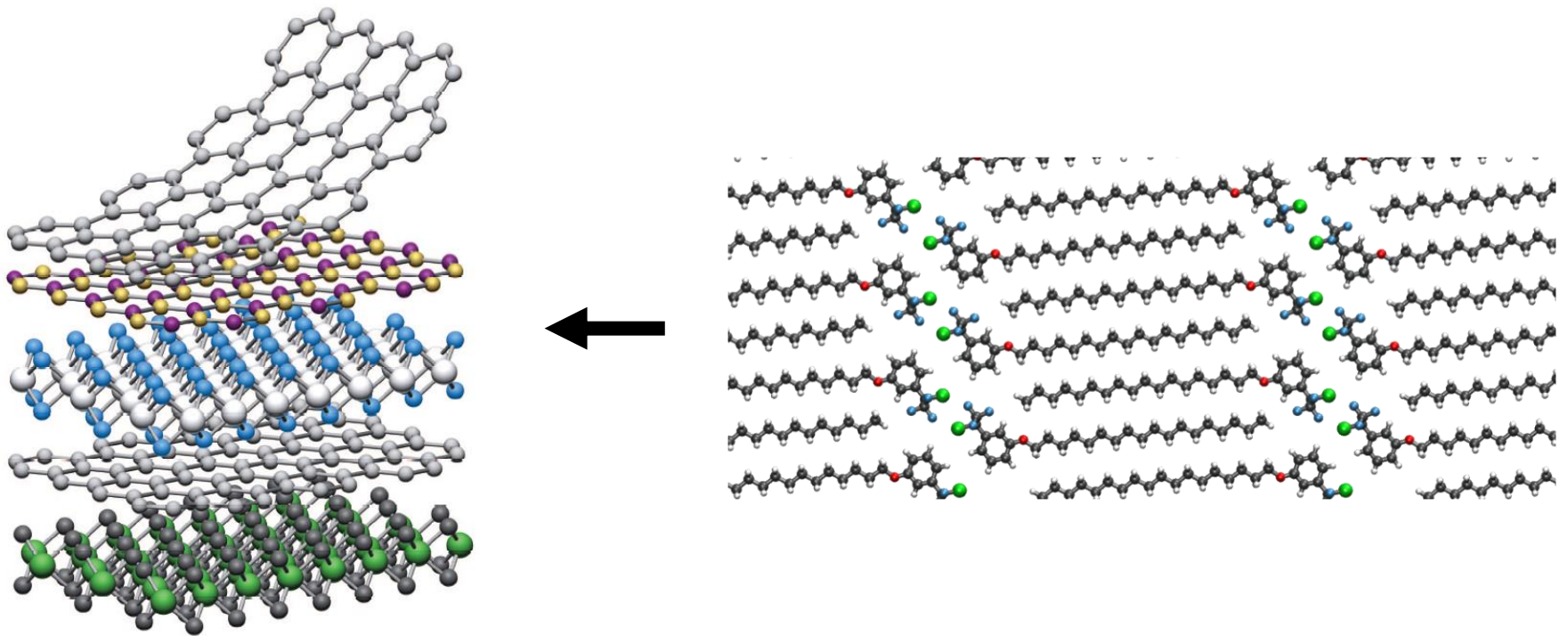


M. Gobbi *et al.* *Nature Commun.*, 8:14767 (2017)

Perspective:

- ✓ Apply the approach to other 2D materials
- ✓ Test other geometries of the assembly

Van der Waals heterostructures



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Technical University Dresden

Prof. Xinliang Feng

Fundings

FP7 FET Open Project “bottom-UP blueprinting GRAphene baseD Electronics” (UPGRADE)

Graphene flagship (GA-696656)



GRAPHENE FLAGSHIP

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Thank you all

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GRAPHENE FLAGSHIP