Electronic properties of stacked two-dimensional crystals

Impact of long-range atomic ordering and periodic potentials

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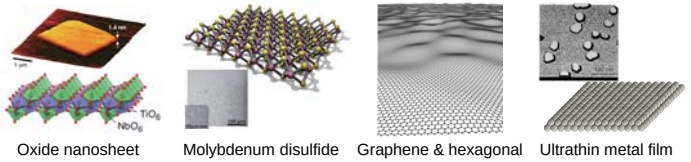
Scope: Advent of graphene and other 2D-crystals drives the development of hybrid 2D-crystal stacks that exploit the unique properties owing to their low dimensionality. Our research activity addresses: (1) how azimuthally misoriented graphene sheets couple electronically, and (2) how we study more complex 2D-crystal stacks using low energy electron microscopy?

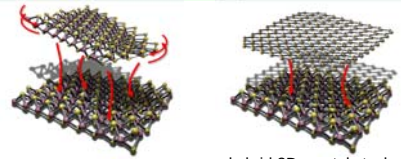


Oxide nanosheet — Osada et al., Adv. Funct. Mater. 21, 3482 (2011)

Molybdenum disulfide — Lee et al., Advanced Materials, 24, 2320 (2012)

Graphene & hexagonal boron-nitride

Ultrathin metal film — Su et al., PRL 86, 5116 (2001)

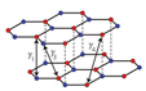


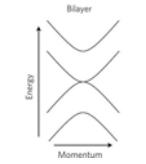
Azimuthal misorientation — http://www.jameshedberg.com,

hybrid 2D-crystal stacks — http://www.123rf.com

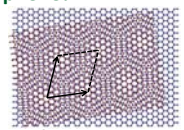
Twisted Bilayer Graphene: simplest hybrid 2D-crystal stack

How is misorientation manifested in bilayer graphene?

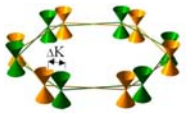




Freitag et al., Nature Physics 7 596 (2011)

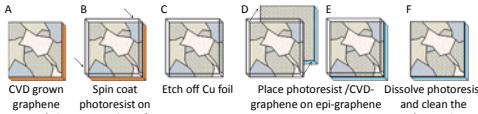


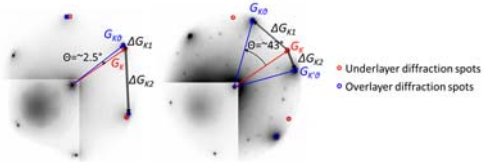
Moiré lattice produced by overlapping graphene sheets



http://www.physics.rutgers.edu/~aluican/research.html

Transferring CVD graphene onto another graphene yields large TBG domains with various twist angles

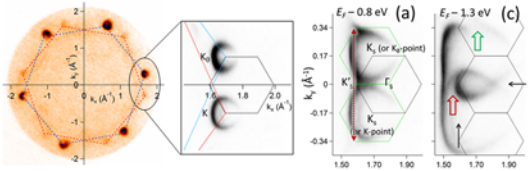




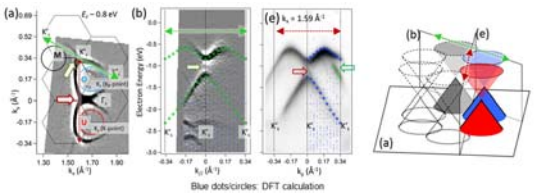
Ohta, Kellogg, et al., PRB, 85, 075415 (2012)

Interlayer interaction & moiré's periodic potential modulate TBG's electronic dispersion

Deviation from single layer behavior due to interlayer coupling

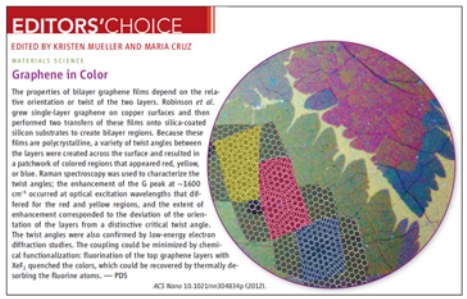


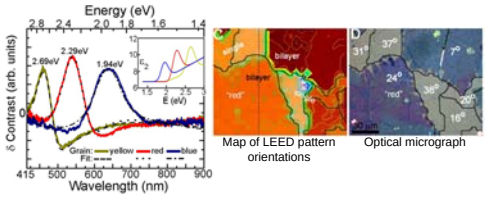
Moiré's periodic potential induces additional Dirac cones



Ohta, Feibelman, et al., PRL, 109, 186807 (2012)

Electronic coupling affects the properties of TBG





Robinson, Diaconescu, Ohta, et al, ACS Nano, 7, 637 (2013)
Featured in Science 152, 374 (2013), "editor's choice"

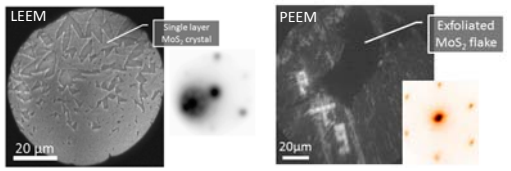
Future work

Morphology, atomic arrangement, and electronic properties of hybrid 2D-crystal stacks:

graphene, MoS_2, h-BN

MoS_2 monolayer grown on SiO_2

MoS_2 flakes on epitaxial graphene grown on SiC

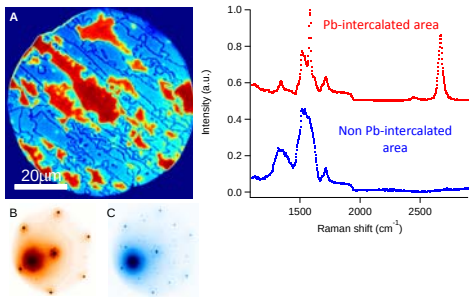


Mann, Ohta, Diaconescu, Kellogg, Bartels, et al., accepted to European Phys. J. B (2013)

In collaboration with Prof. L. Bartels, UC Riverside and Dr. J. T. Robinson at Naval Research Laboratory

Ultrathin metal film covered with graphene:

Extending the choices of 2D-crystal to 3D-materials



Atomically-thin Pb film intercalated beneath graphene

New Pb-induced interface structure is probed using LEED and Raman spectroscopy

National Nuclear Security Administration

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