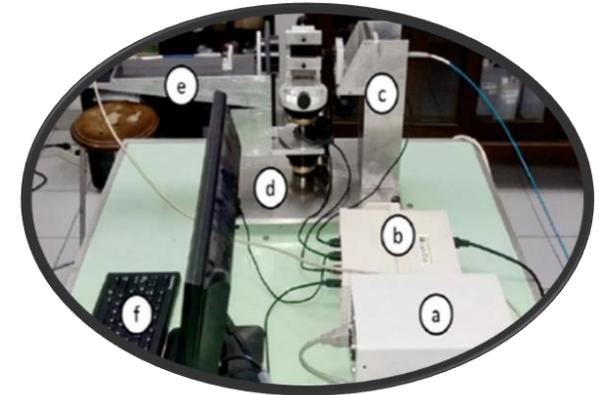
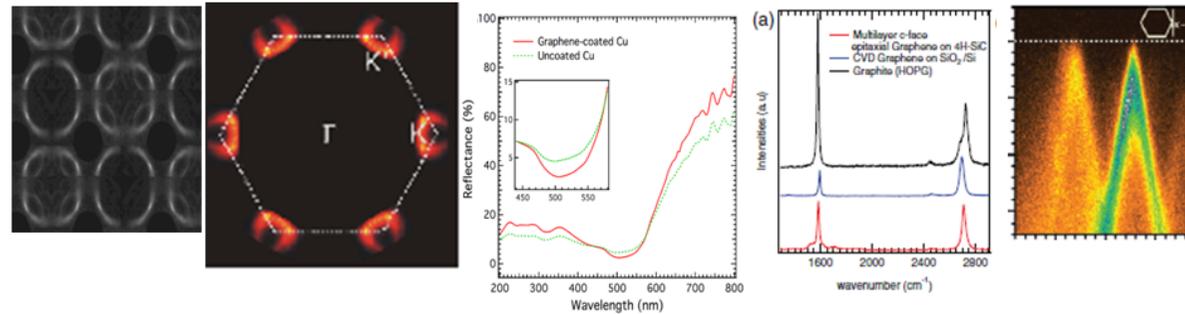


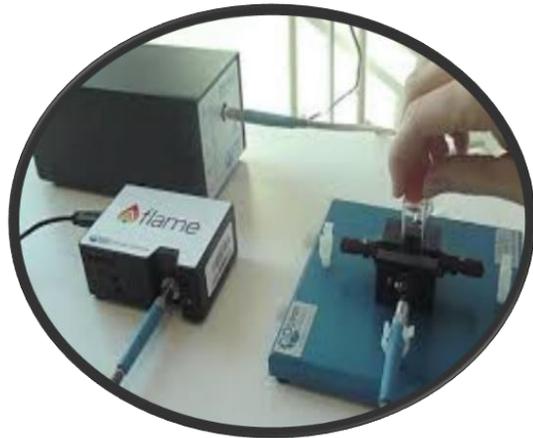


Raman Spectroscopy

# Emerging Quantum and Novel Material SPECTROSCOPIES



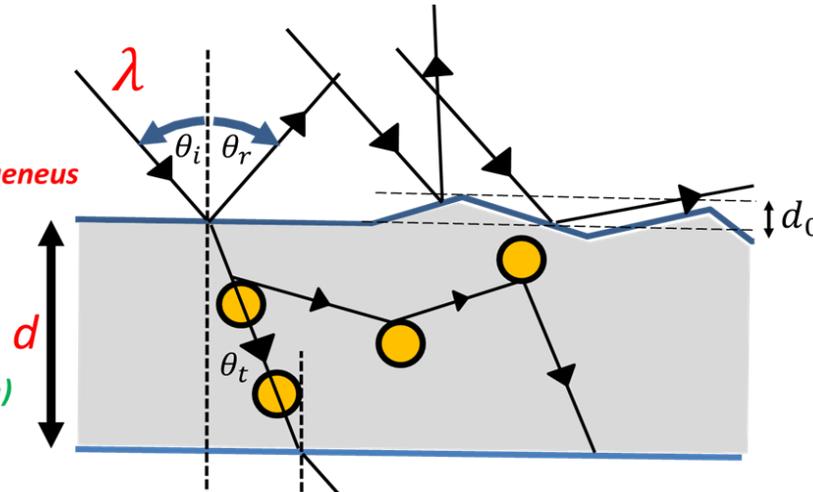
Spectroscopic Ellipsometry  
Dana et al , Eur. J. Phys. 108, 37009 (2020)



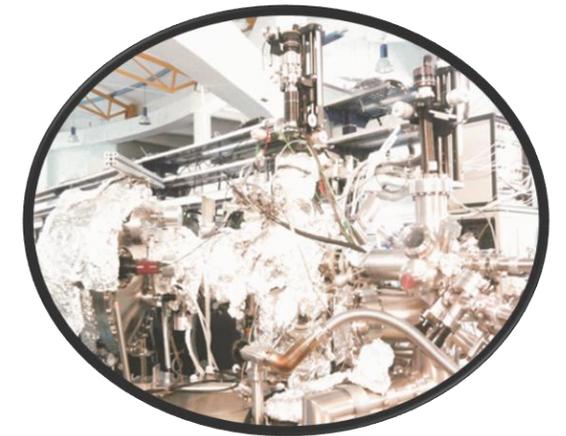
Photoluminescence/Reflectance Spectroscopy

*Bulk*  
*Thin Film*  
*Linear – non linear*  
*Isotropic – anisotropic*  
*Homogeneous - inhomogeneous*

*Specular-difussive*  
*Reflection(pantulan)*  
*Absorption(serapan)*  
*Refraction(pembiasan)*  
*Transmission(penerusan)*  
*Scattering(hamburan)*  
*Emission/Luminescence*



**Spectroscopy** : *probing the interaction between electromagnetic wave and matter (including biological tissue)*



Photoelectron/Photoemission Spectroscopy  
(Access to several Synchrotron Light Source)

## (i) Hamiltonian Tight Binding:

$$H = -t \sum_{\langle i,j \rangle} c_i^\dagger c_j + \epsilon_d \sum_k d_k^\dagger d_k + V \sum_k (d_k^\dagger c_k + H.c.),$$

## (ii) Density of States (DOS):

$$\rho(\epsilon) = \lim_{S \rightarrow \infty} \frac{1}{S} \sum_{p=1}^S d_p(\epsilon)$$

Trotter-Suzuki decomposition

$$d(\epsilon) = \frac{1}{2\pi} \int_{-\infty}^{\infty} e^{-i\epsilon t} \underbrace{\langle \varphi | e^{-iHt} | \varphi \rangle}_{\text{TDSE}} dt$$

Solusi Time dependent Schrodinger Eq (TDSE)

$$|\varphi\rangle = \sum_i a_i |i\rangle,$$

## (iii) Optical (ac) conductivity:

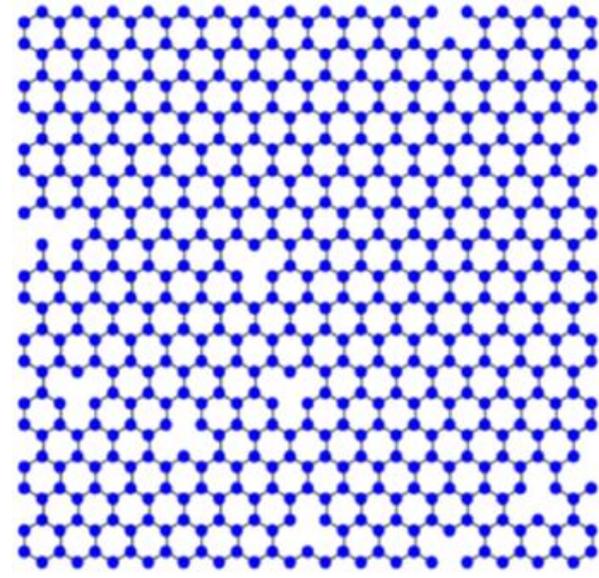
$$\text{Re} \sigma_{\alpha\beta}(\omega) = \lim_{\epsilon \rightarrow 0^+} \frac{e^{-\hbar\omega/k_B T}}{\hbar\omega A} \int_0^\infty e^{-\epsilon t} \sin(\omega t) 2C_{AC}(t) dt,$$

$$C_{AC}(t) = \text{Im} \langle \psi_2(t) | J_\alpha | \psi_1(t) \rangle_\beta. \quad f(H - \mu) = \frac{1}{e^{\beta(H - \mu)} + 1},$$

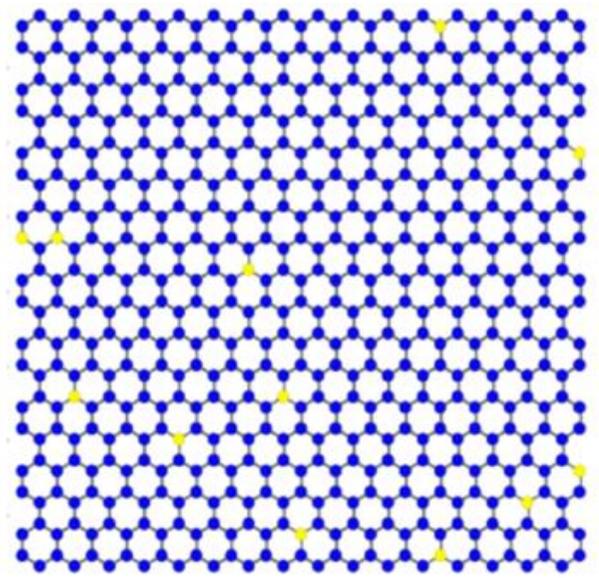
$$|\psi_1(t)\rangle_\beta = e^{-iHt} [1 - f(H - \mu)] J_\beta |\psi(0)\rangle, \quad J_\alpha = -\frac{ie}{\hbar} \sum_{i,j} t_{ij} (\mathbf{r}_j - \mathbf{r}_i)_\alpha c_i^\dagger c_j,$$

$$|\psi_2(t)\rangle = e^{-iHt} f(H - \mu) |\psi(0)\rangle.$$

vacancies



adatoms



## (iv) Transport (dc) conductivity:

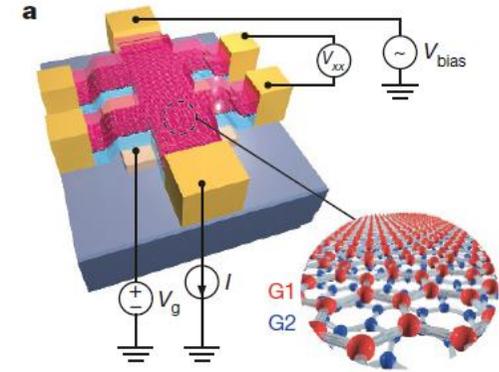
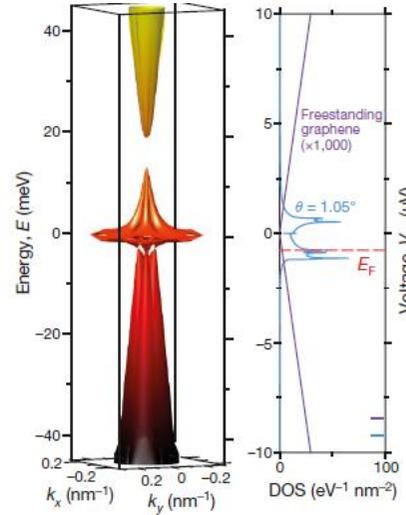
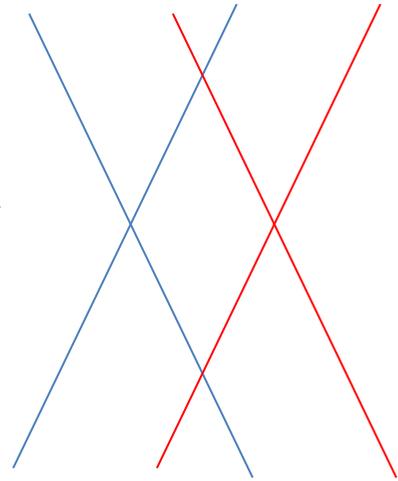
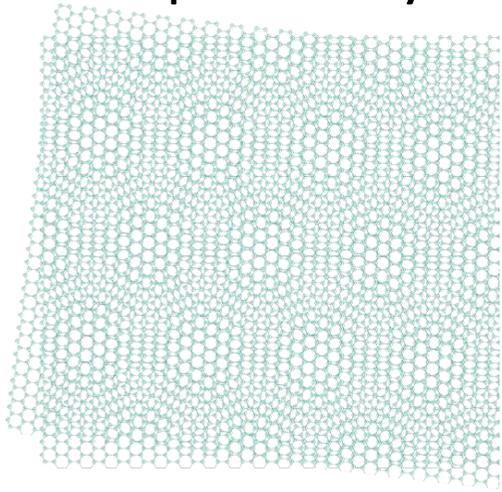
$$\sigma_\alpha(E) = \frac{d(E)}{A} \int_0^\infty \text{Re} [e^{-iEt} C_{DC}(t)] dt,$$

$$C_{DC}(t) = \frac{\langle \psi(0) | J_\alpha e^{iHt} J_\alpha | \psi(E) \rangle}{|\langle \psi(0) | \psi(E) \rangle|},$$

$$|\psi(E)\rangle = \frac{1}{2\pi} \int_{-\infty}^\infty e^{iEt} |\psi(t)\rangle dt,$$

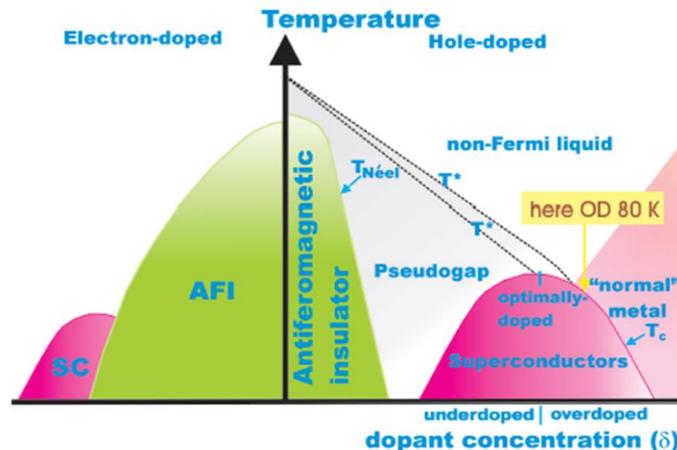
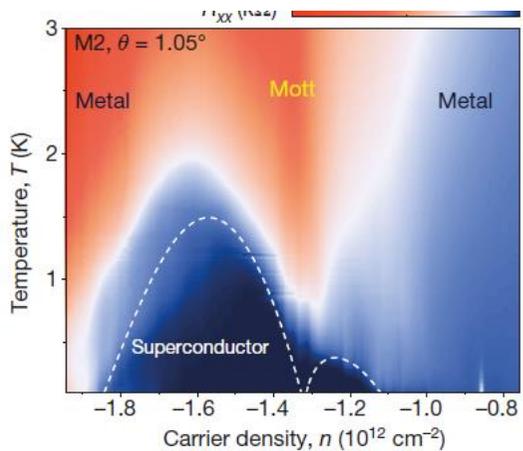
# van der Waals Heterojunction dengan untiran: twisted bilayer graphene

Graphene layer



Moire superlattice

Band dispersion



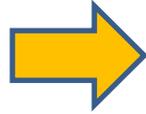
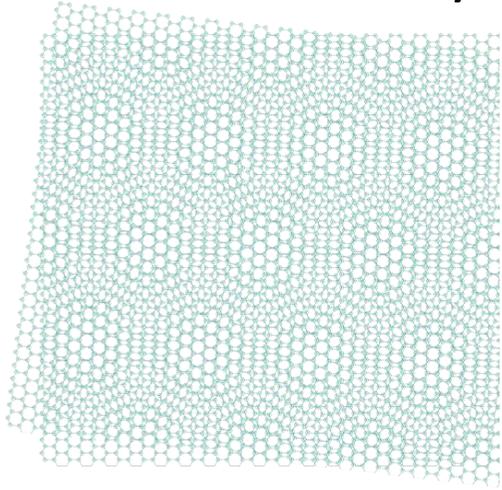
tBG sebagai playground kajian fundamental material terkorelasi

Tuning parameter : *gate voltage only*

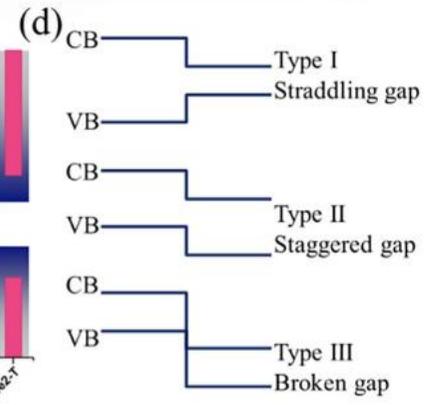
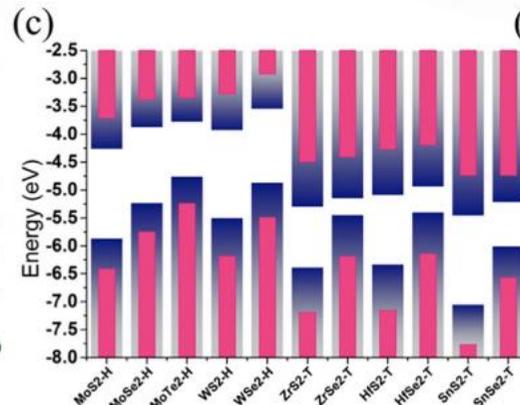
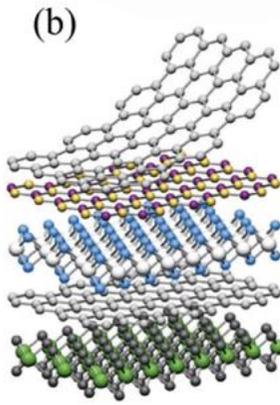
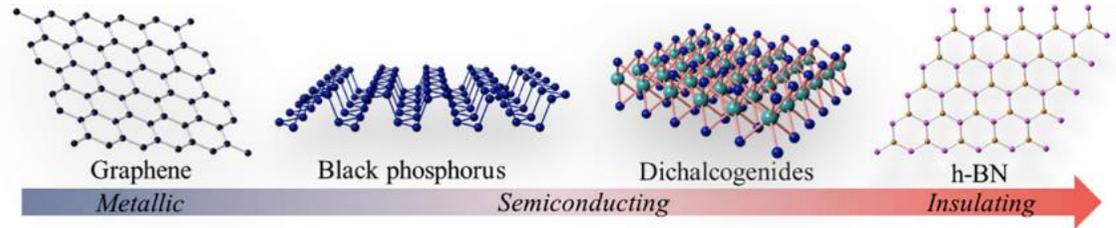
Cao et al, Nature (2018)

# van der Waals Heterojunction dengan untiran: twisted bilayer graphene

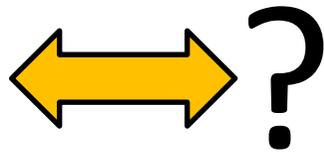
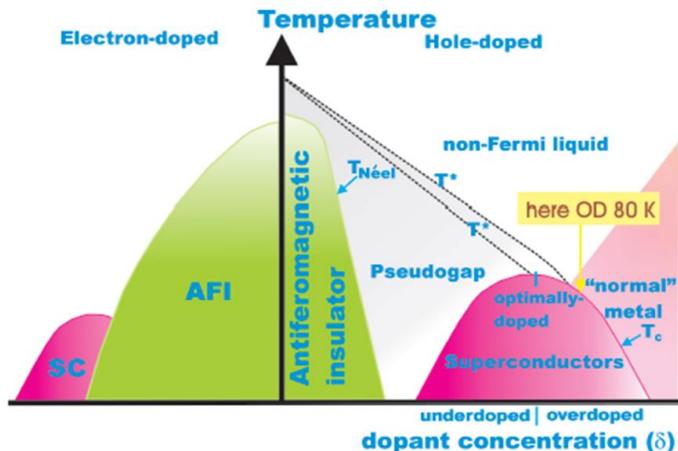
2D material layer



Moire superlattice

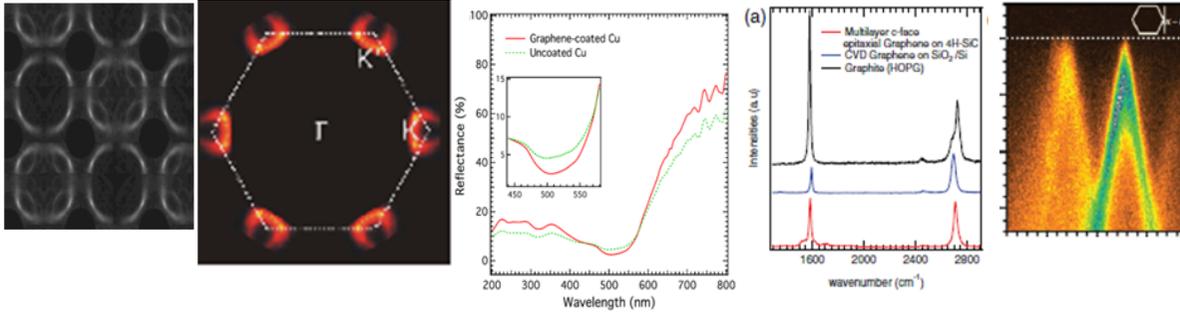


Liao et al, App. Mat. Today (2019)



- ❖ Twisted van der Waals heterojunctions sebagai playground baru untuk kajian fundamental material terkorelasi
- ❖ Tuning parameter : *gate voltage only*
- ❖ *Superconductivity? Magnetic? Optoelectronics*

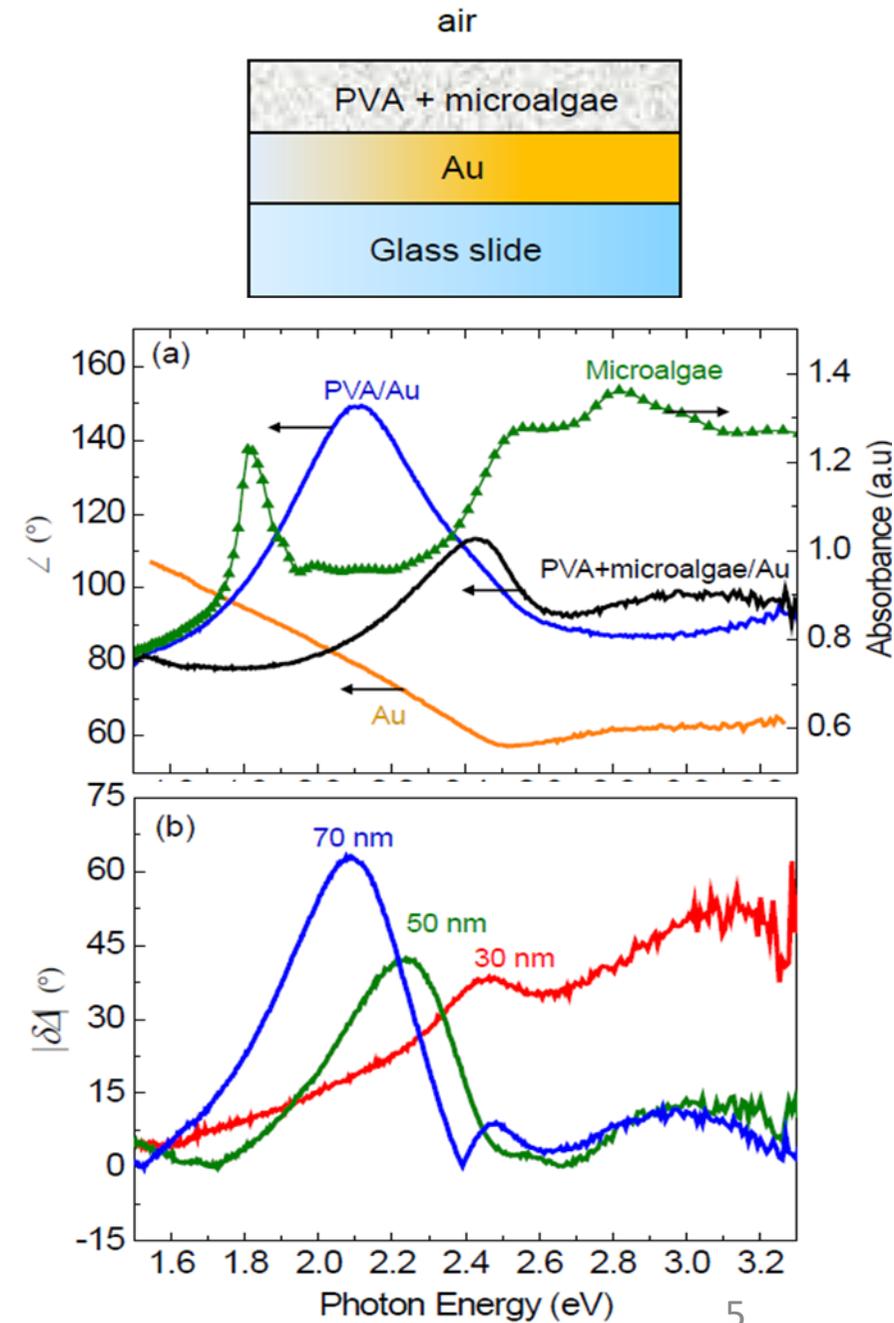
# Emerging Quantum and Novel Material SPECTROSCOPIES



## Ellipsometry Based Biosensor (Au and Cr thin film) for Microalgae Detection

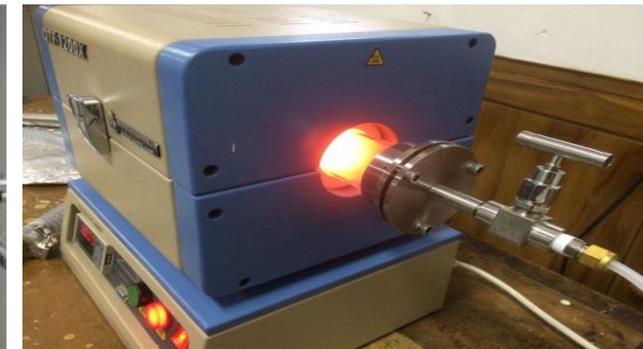
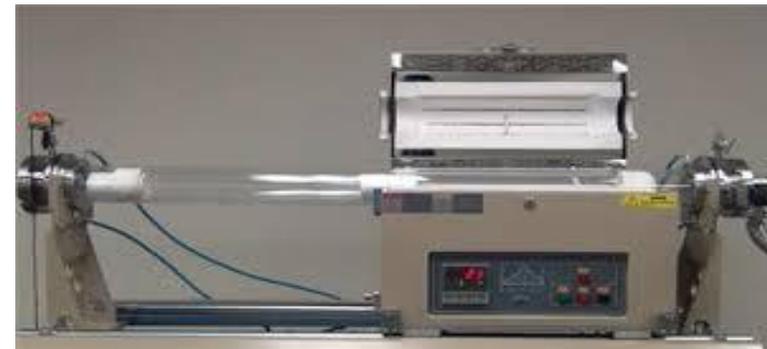
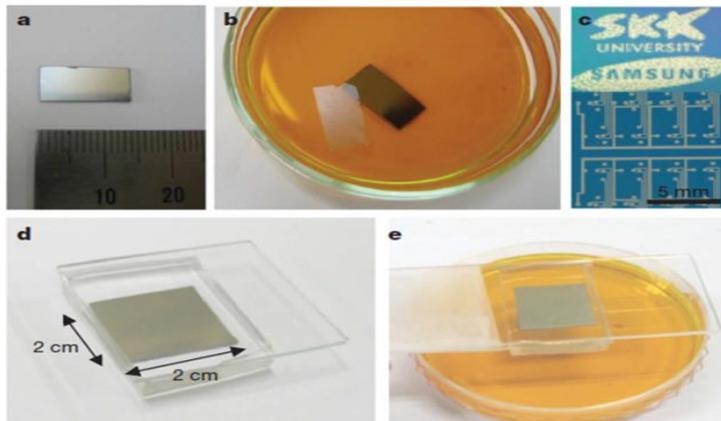
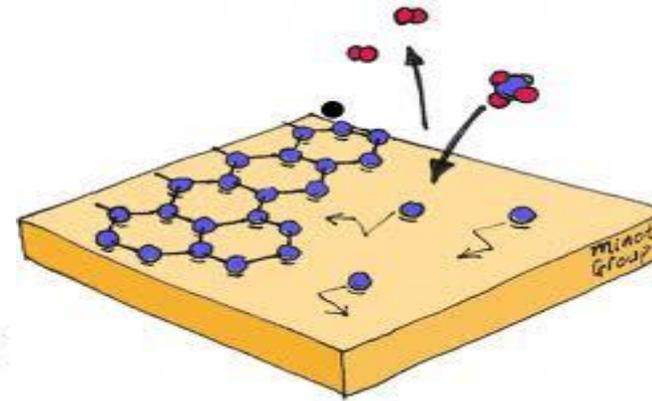
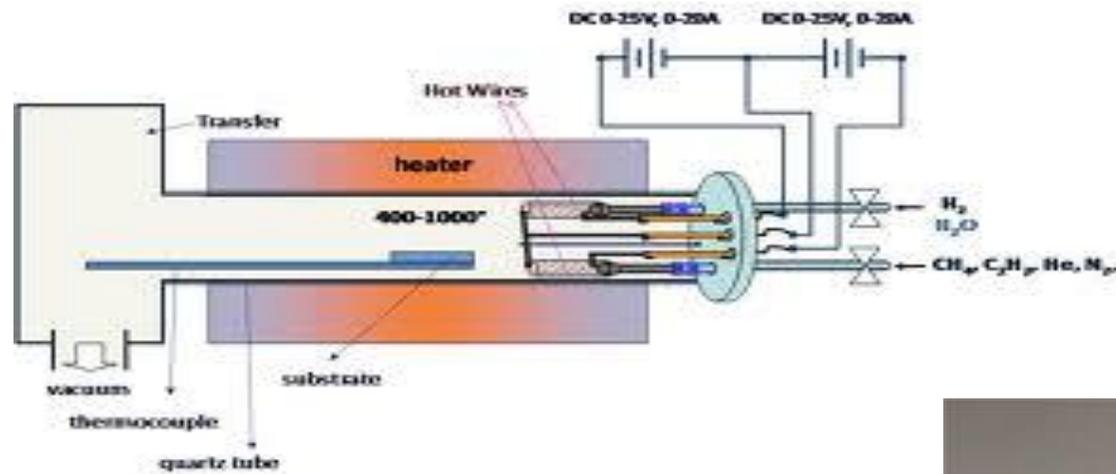


Khasanah *et al* , *Key Eng. Mat.* 840, 412 (2020)



# Quantum Materials : the synthesis

## Graphene CVD : Chemical Vapour Deposition

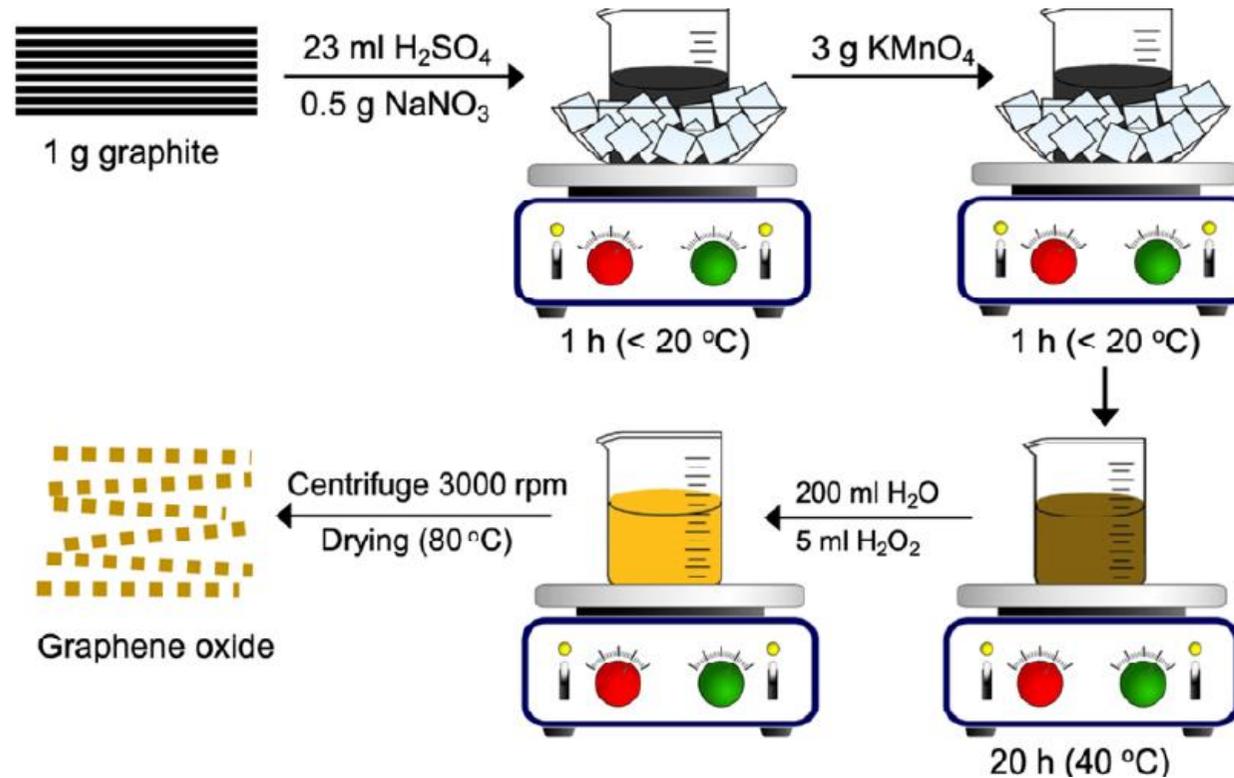


CVD Reactor at Physics Dep. UGM

Transfer to other substrate

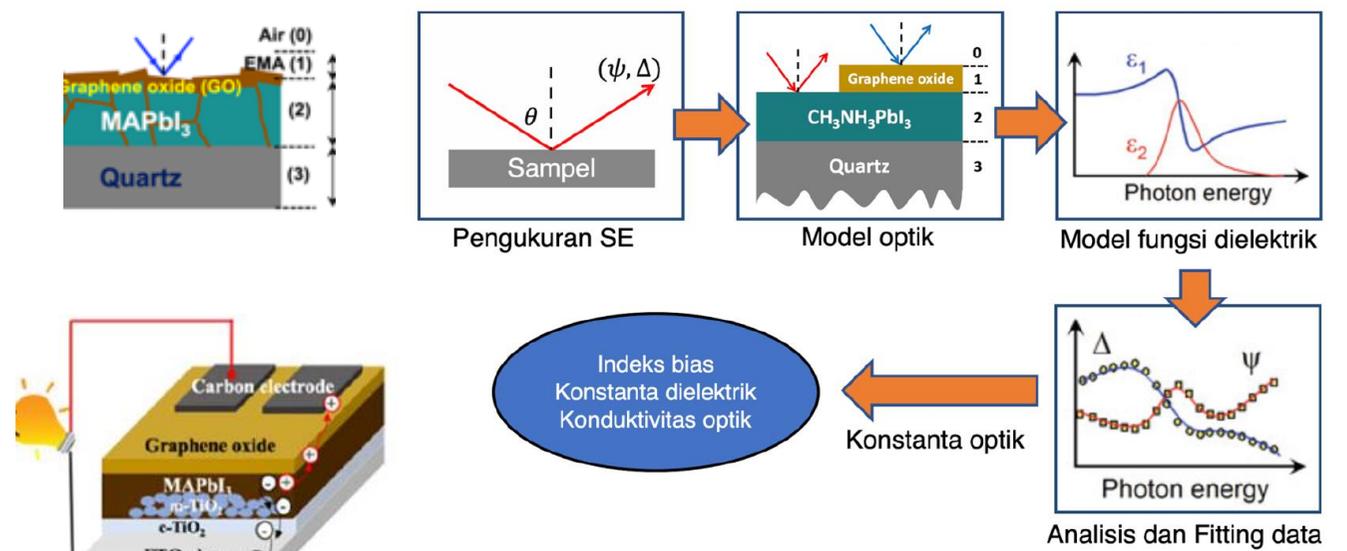
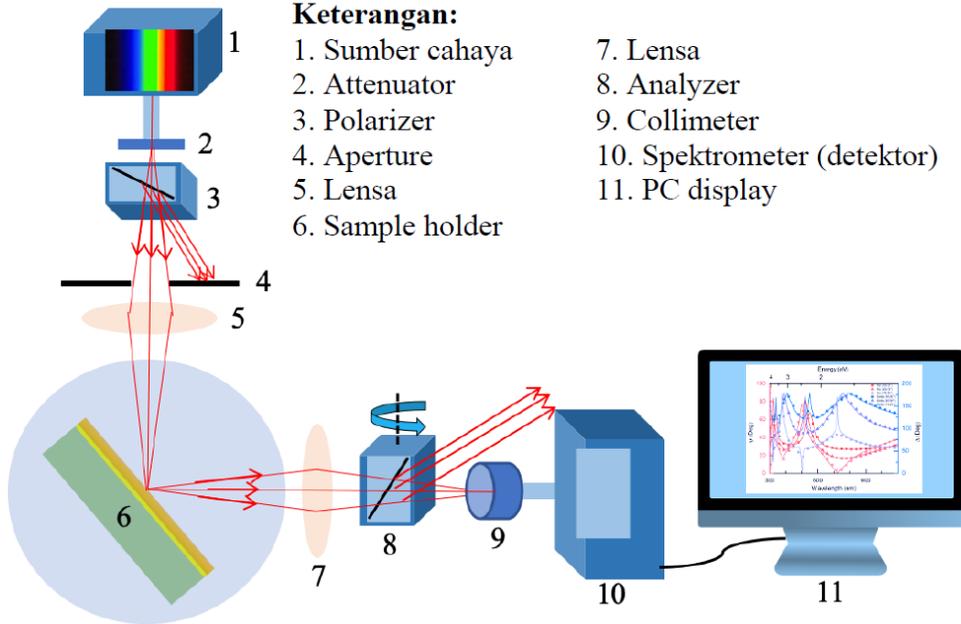
# Quantum Materials : the synthesis

## ✓ *Wet chemistry: graphene oxide dan reduced graphen oxide*

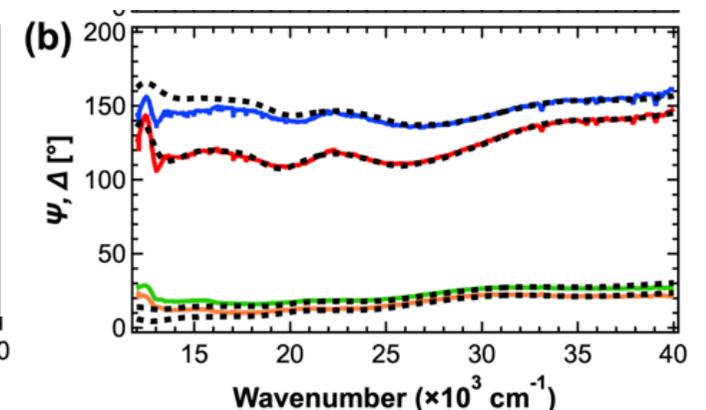
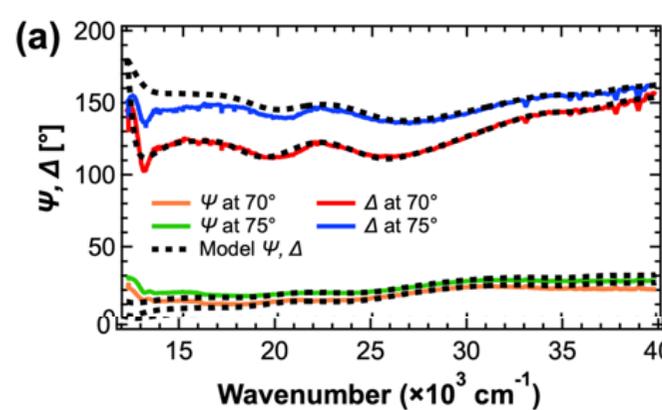
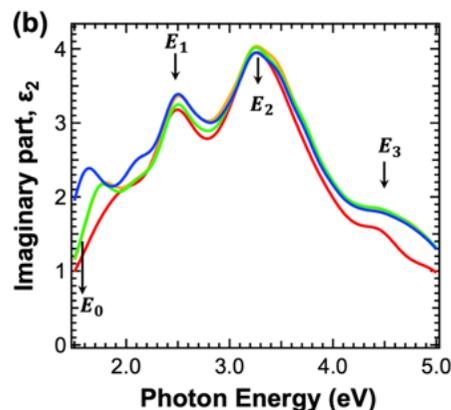
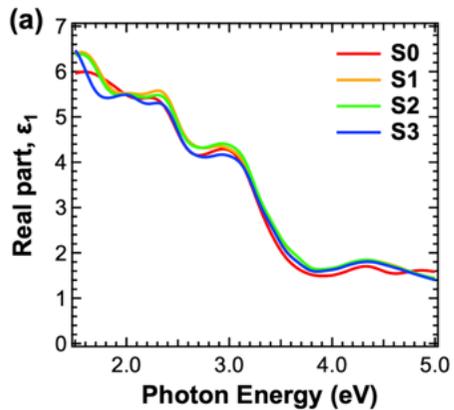


Widianto et al *Adv. Nat. Sci.: Nanosci. Nanotechnol.* 12 (2021)

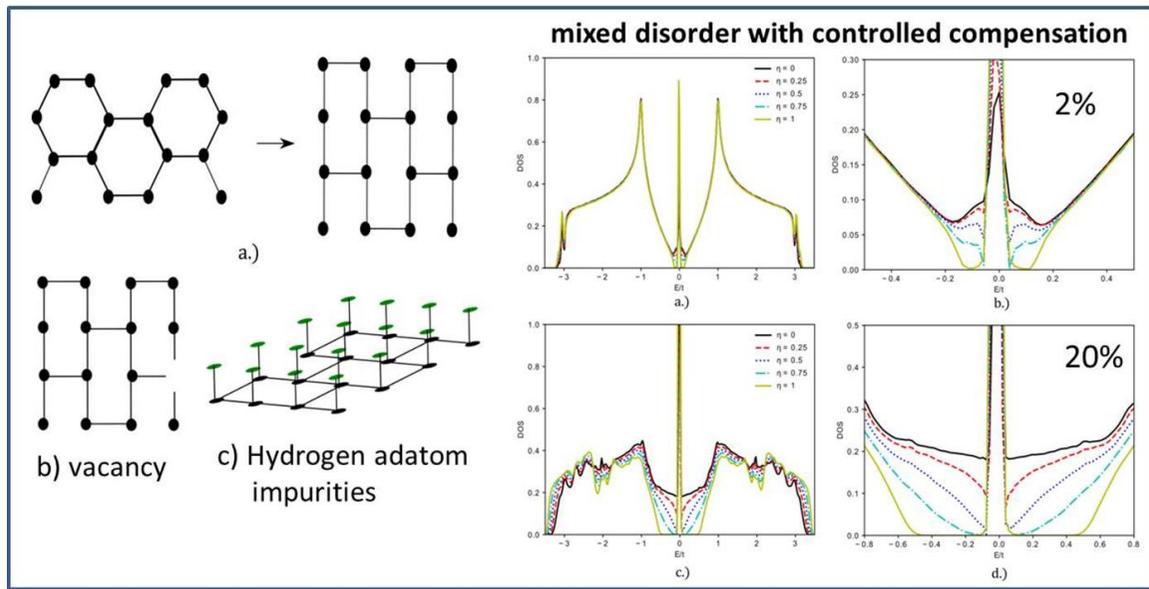
# Kajian Sifat Optik Material 2D pada Sel Surya organik



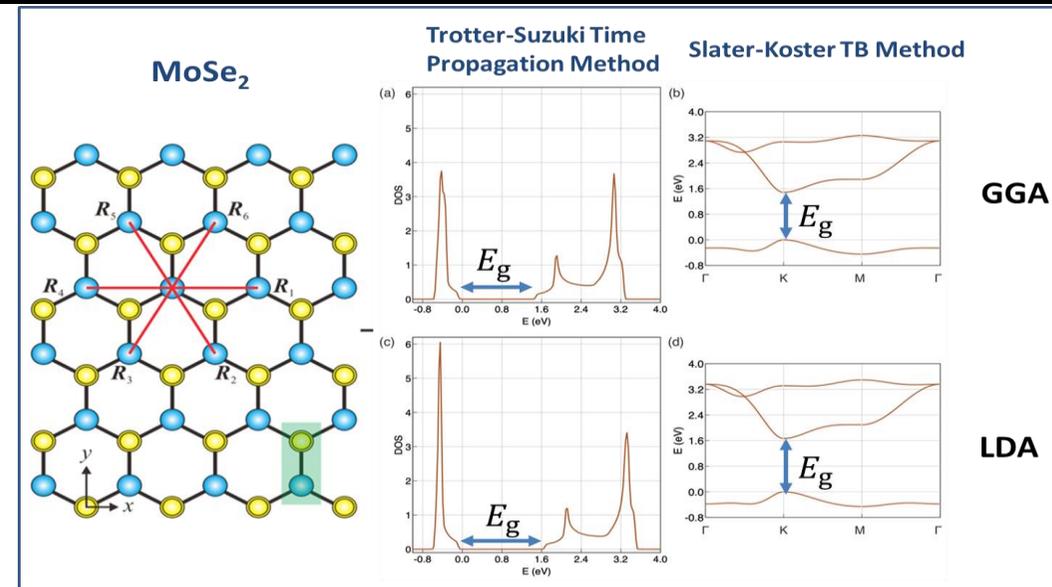
Widianto et al (2021), (under review)



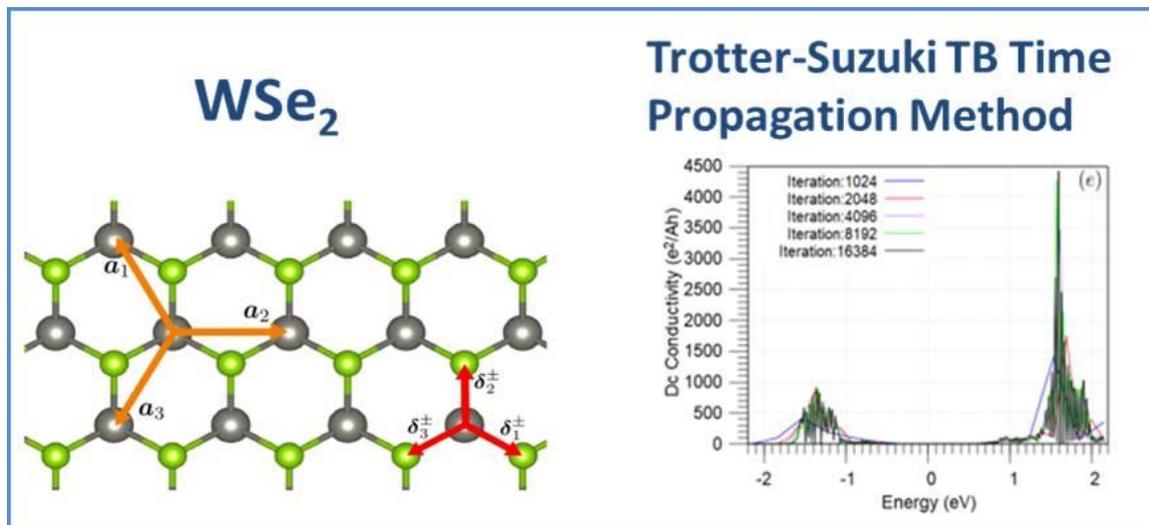
# Modeling Quantum Materials in large scale : *Tight Binding – Time Propagation Method*



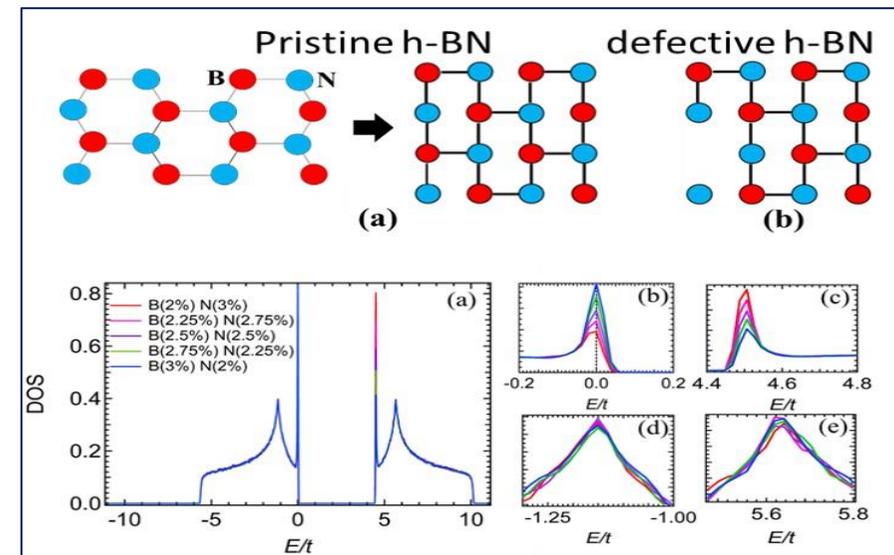
Ariasoca et al, Com. Mat. Sci. 156, 434 (2019)



Harish et al, *submitted*

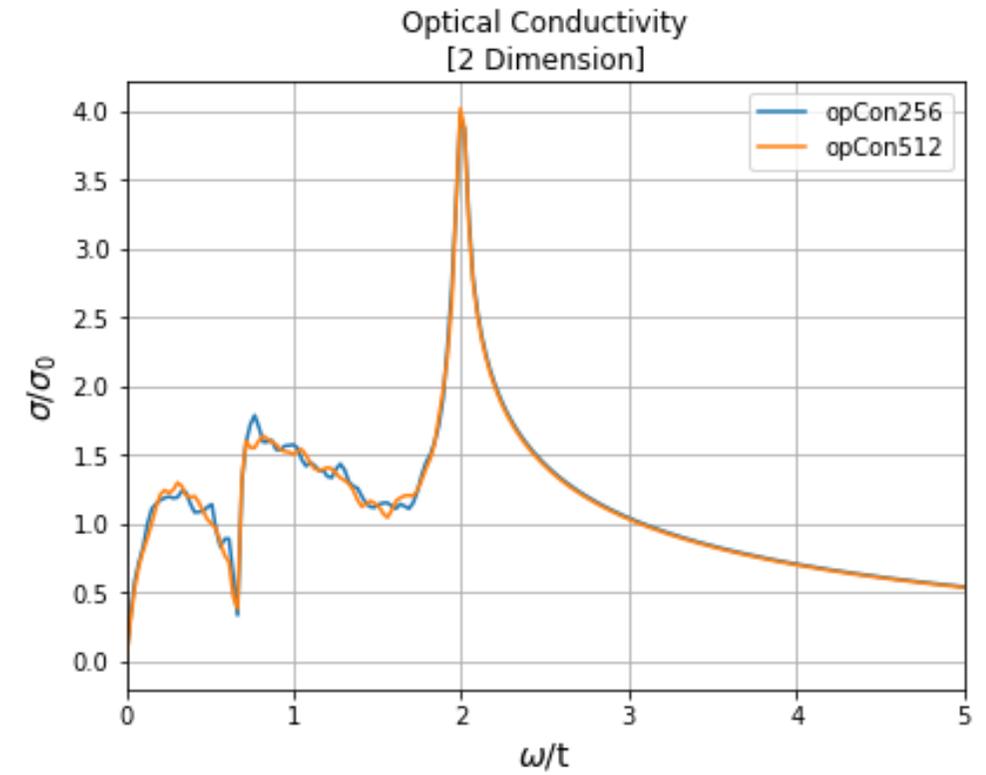
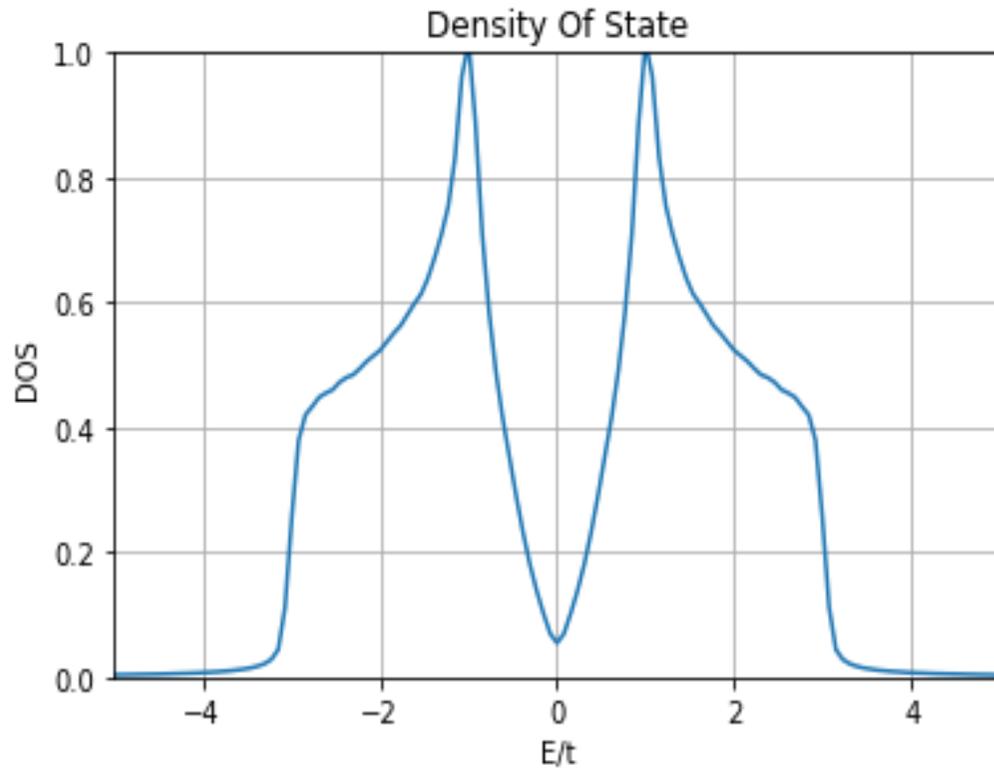
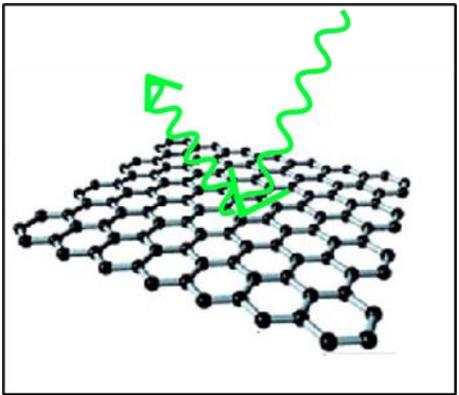


Sara et al, *submitted*



Nugroho et al, *submitted*

# Modeling Quantum Materials in large scale : *Tight Binding – Time Propagation Method*



- Kajian komputasi struktur elektronik pada material-material 2D emergence seperti graphene, transition metal dicalchogenides (TMD), cuprates, oxide electronics, dan material yang terkorelasi kuat (*strongly correlated electron materials*) menggunakan metode *Tight Binding Time Propagation Method*.
- Kajian Spektroskopi menggunakan ARPES (*Angle Resolved Photoemission Spectroscopy*) dan Spektroskopi Optik (*Ellipsometry, Transmittance, Photoluminescence, Raman*) untuk memahami struktur elektronik material-material emergence/novel dan penerapannya di bidang energi (Sel Surya Organik, Supercapacitors, termoelektrik, superkonduktor) dan sensor.
- Desain dan sintesis material 2D emergence untuk optoelektronik organik dan sensor menggunakan berbagai macam metode seperti CVD (*chemical vapour deposition*), evaporasi vakum (*vacuum evaporation*) dan *wet-chemistry*.

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1. Hibah Kerjasama Luar Negeri (KLN) DIKTI
2. Hibah Penelitian Unggulan Perguruan Tinggi (PUPT) UGM-DIKTI
3. Hibah ICTP – ELETTRA Users Programme
4. Hibah Kompetensi DIKTI, Hibah PDD, RTA UGM



***DIKTI - Kemenristekdikti***  
**-kemendikbud- RTA UGM**



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