Light harvesting properties of Graphene Oxide Nanoribbons

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Solar Powered Nano-Sensors
for data acquisition and surveying in remote areas

National and International Research Alliances Program
Queensland Government Smart Futures Fund 2009-2012

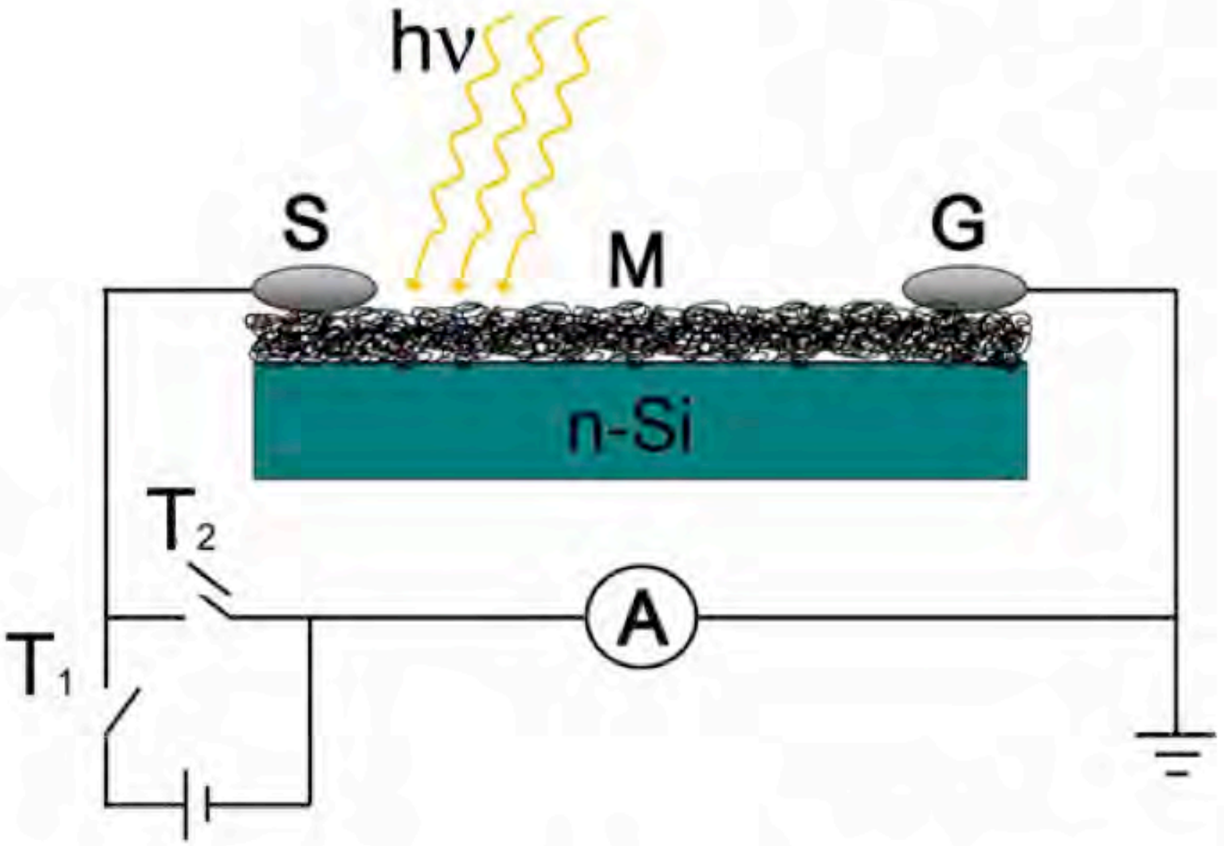
QUT, CQU, Uni Roma Tor Vergata, Uni Brescia, Dyesol

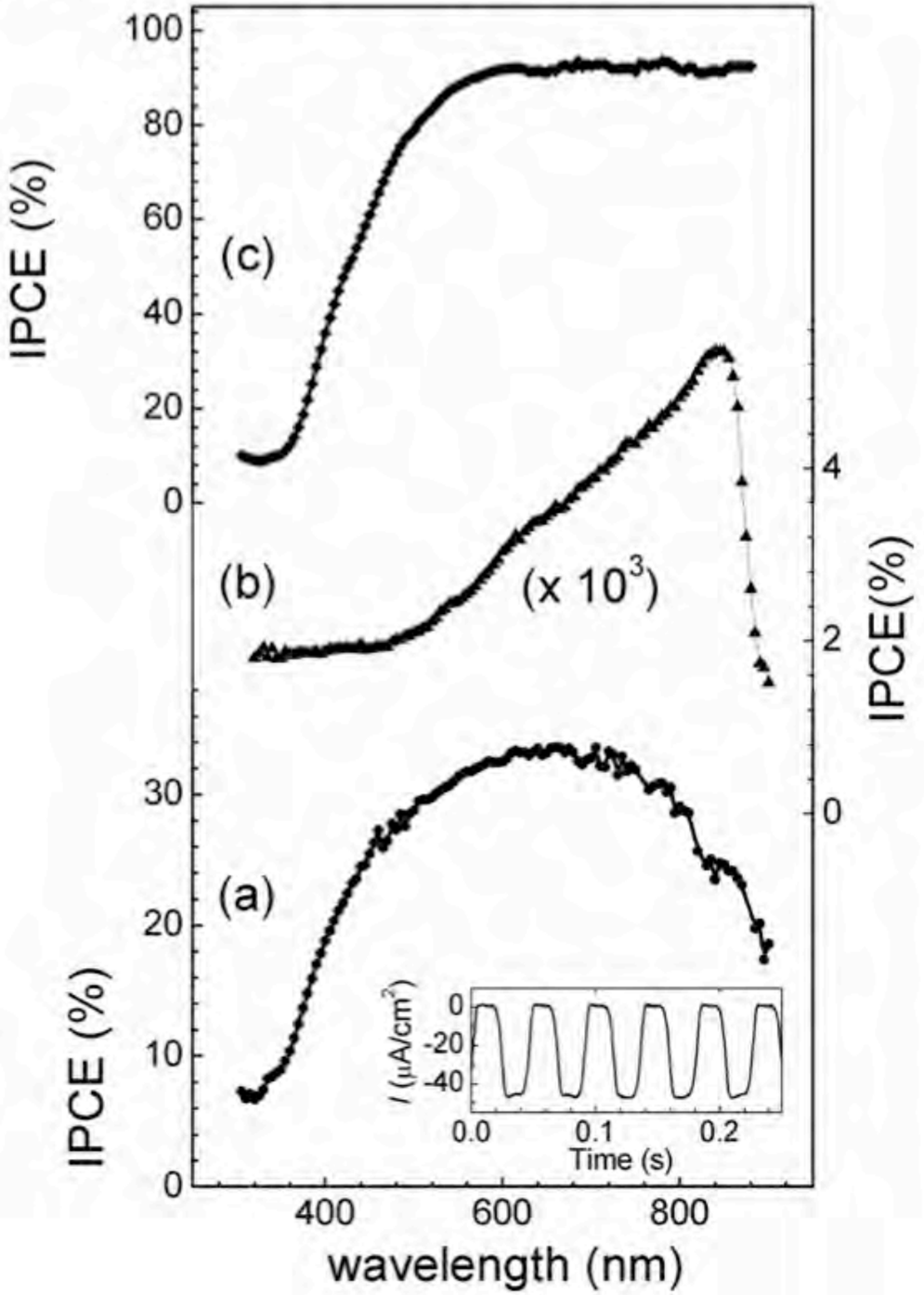
Outline

- "State of the art" of carbon nanotubes and graphene in solar energy conversion
- Production of graphene oxide nanoribbons
- Realization of graphene oxide nanoribbons devices
- Electro-optical characterization of the devices
- Conclusions

MWCNT/Si PV device

Multiple Schottky junctions between metallic CNT and semiconducting Si

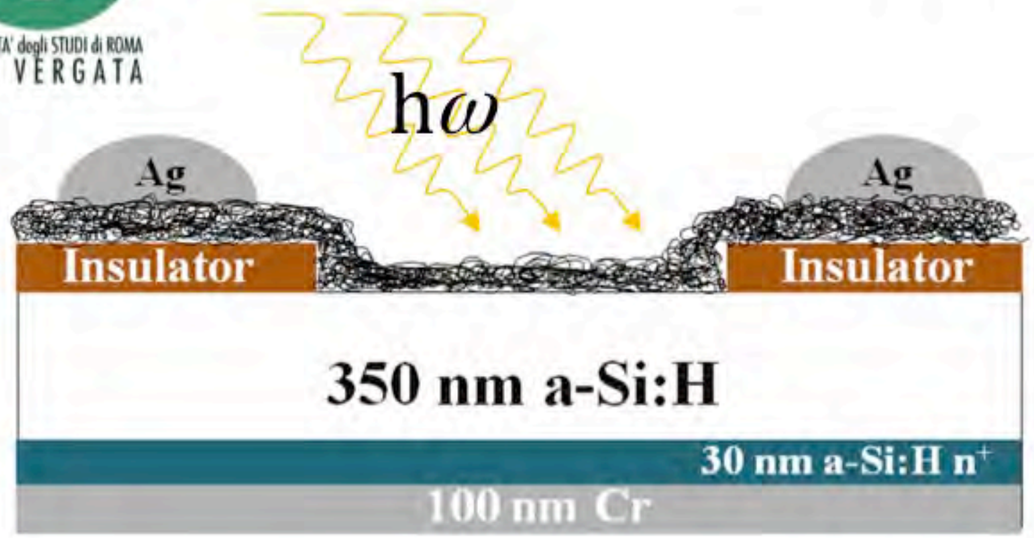




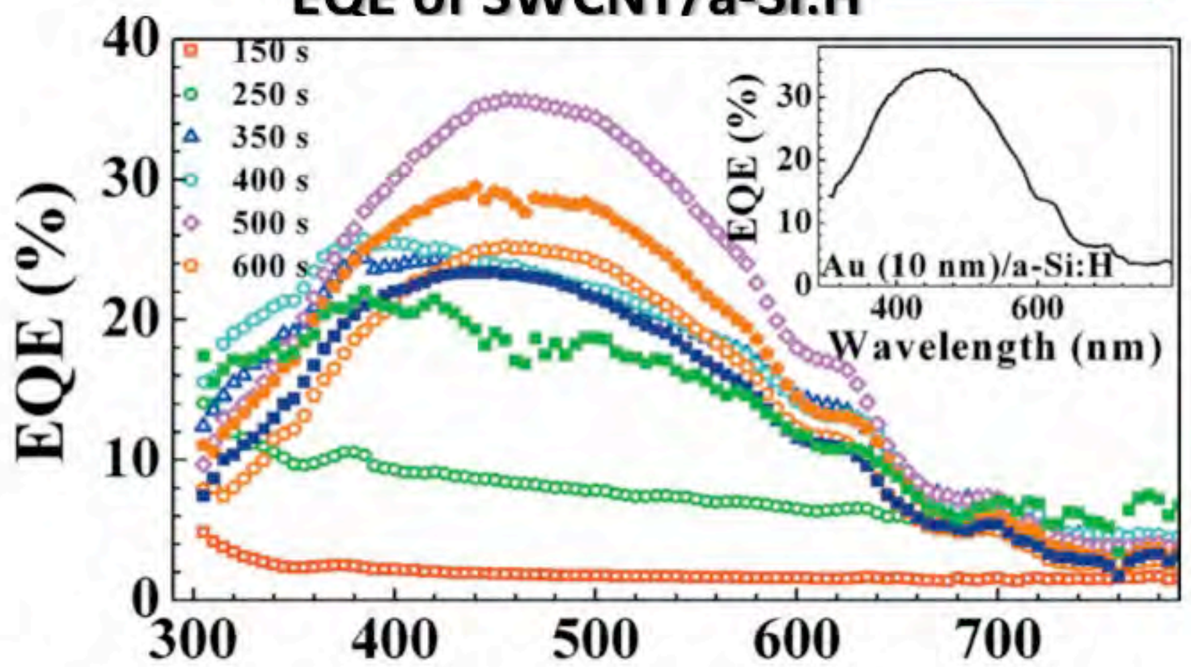
P. Castrucci et al. *Nanotechnology* 22 (2011) 115701

Among top downloaded papers in 2011!

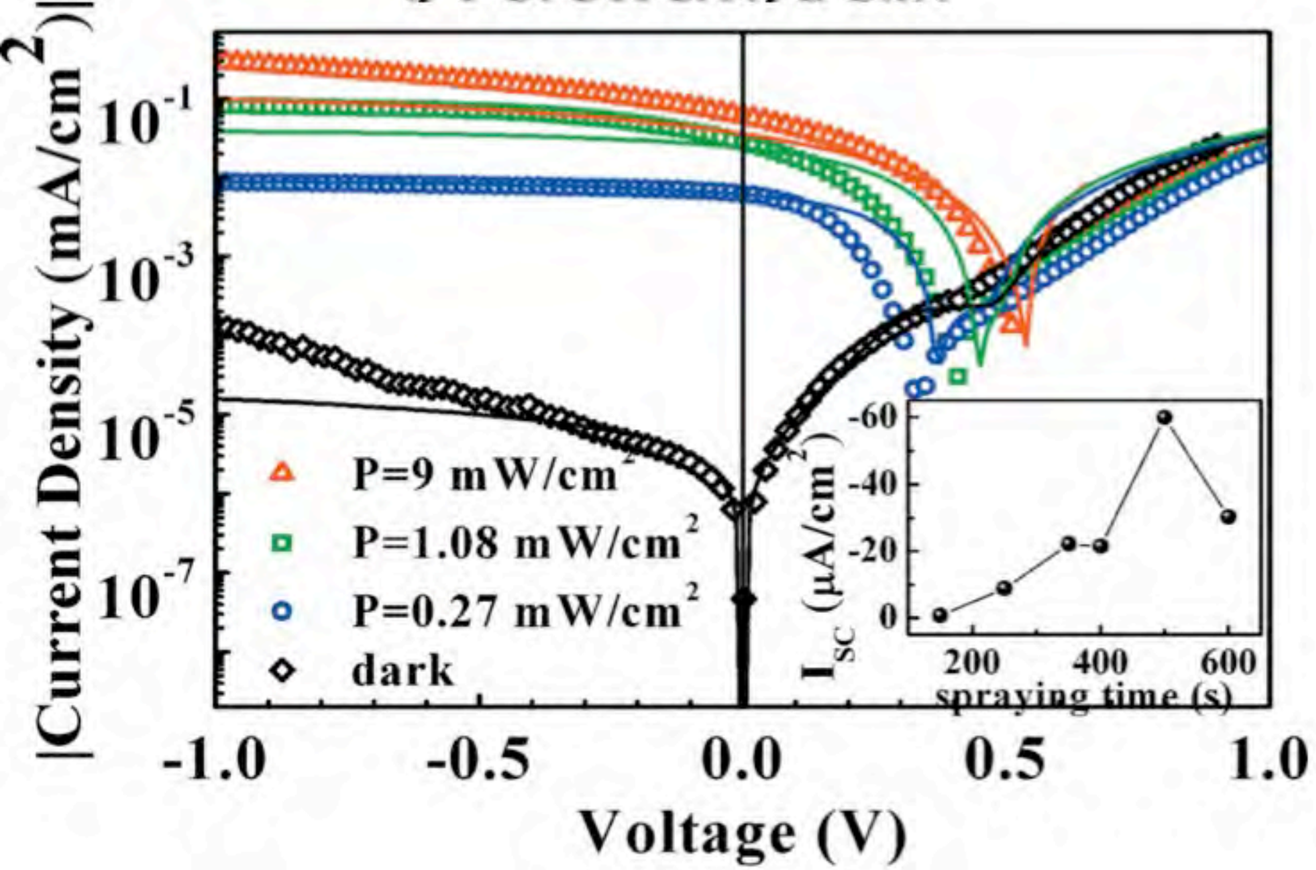
SWCNT/amorphus Si (a-Si:H)

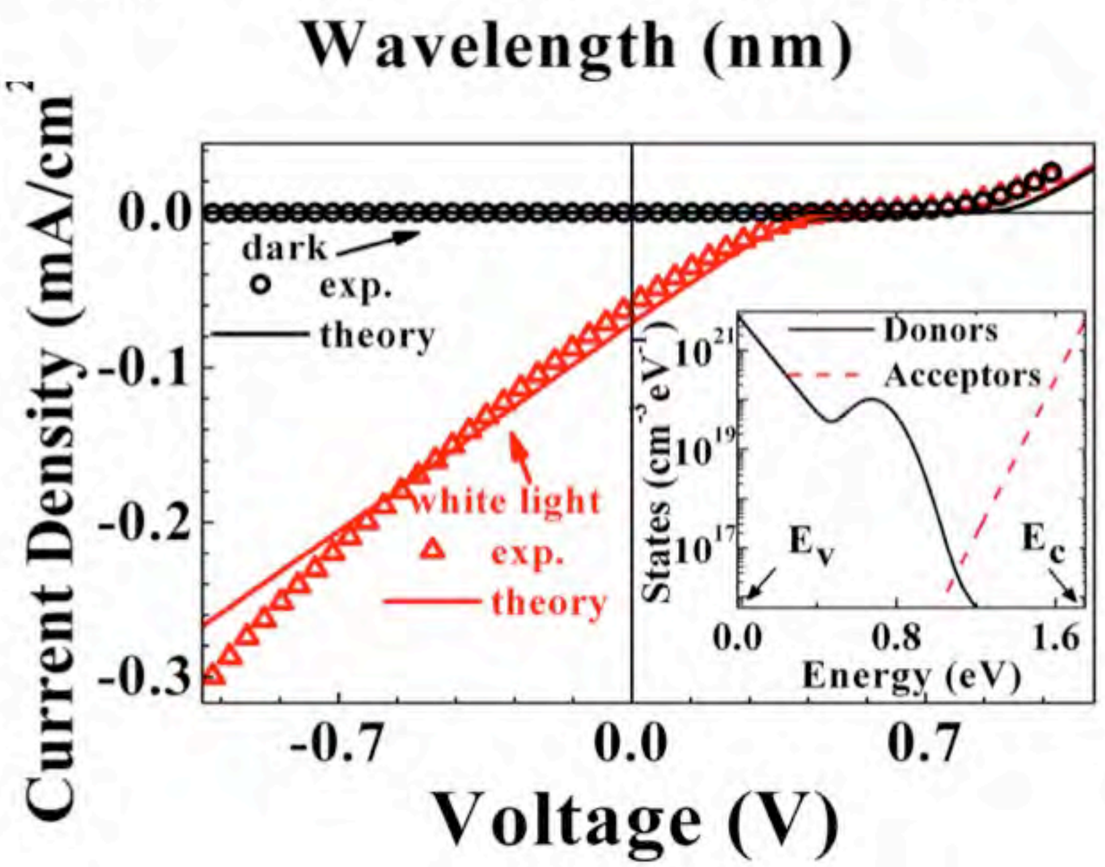


EQE of SWCNT/a-Si:H



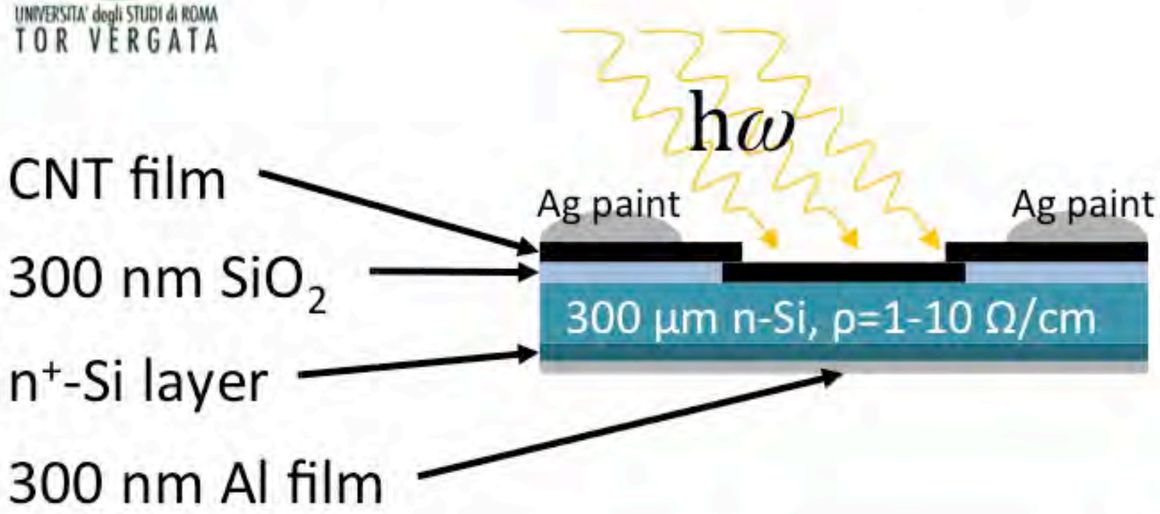
I/V of SWCNT/a-Si:H

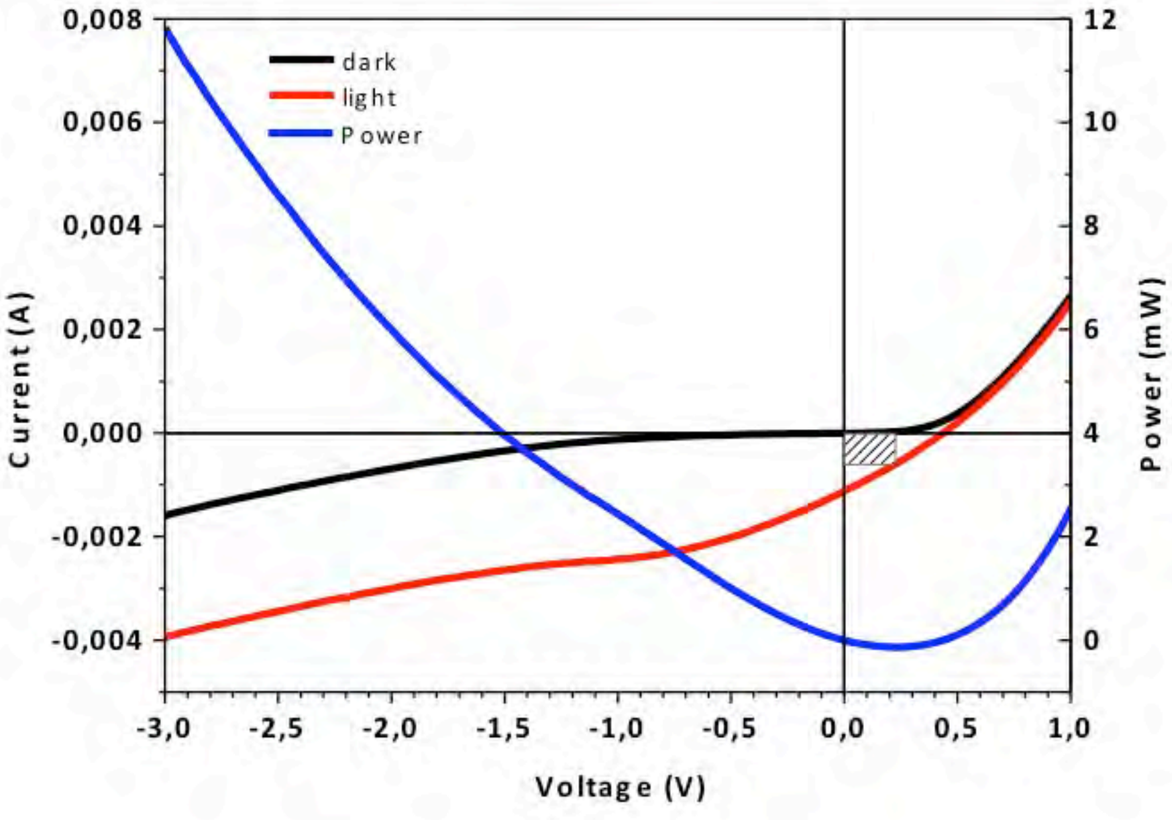


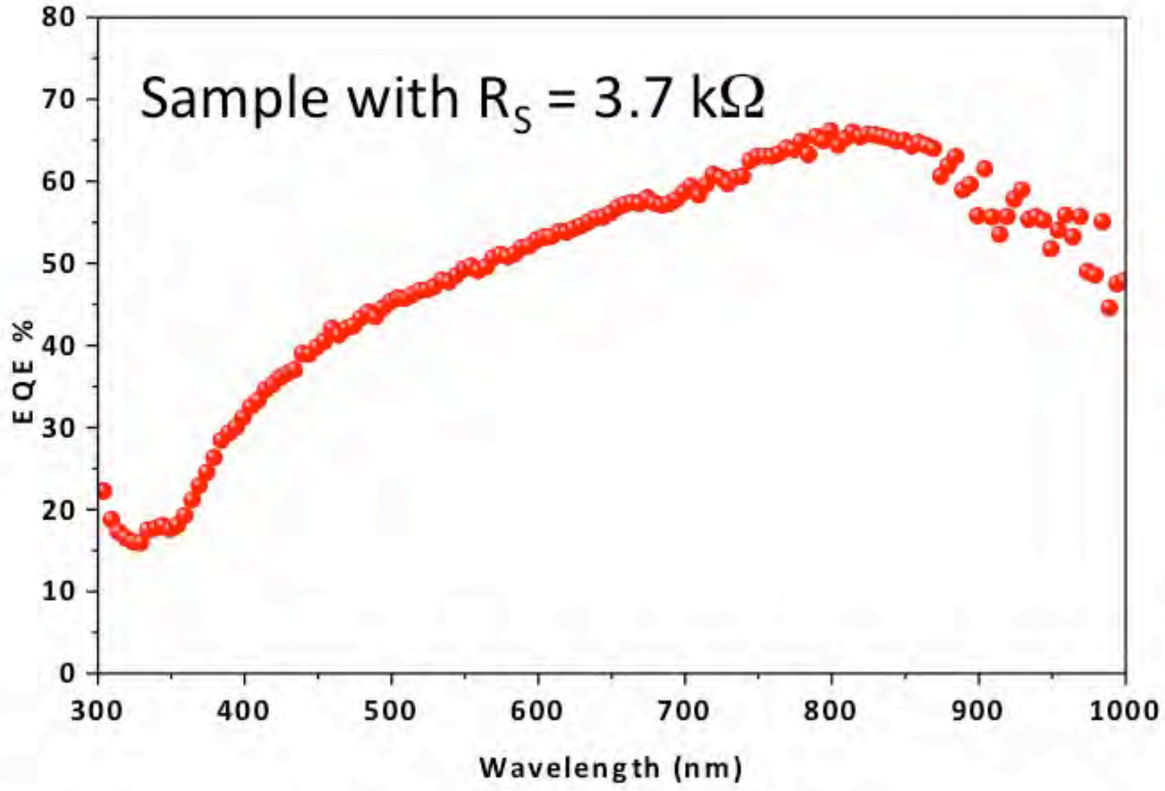


Del Gobbo et al. *Appl. Phys. Lett.* 98 (2011) 183113

SWCNT on Si (ohmic contact)







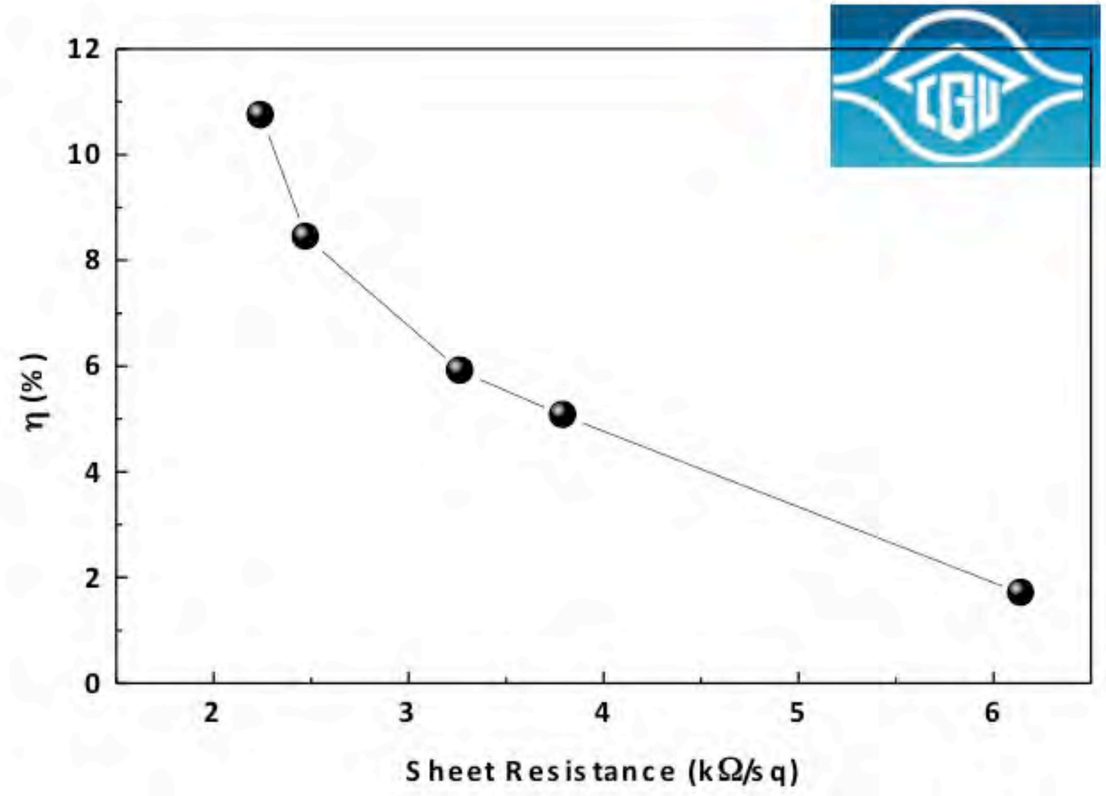
$$FF = \frac{V_{mp} I_{mp}}{V_{0C} I_{SC}} = 0.27$$

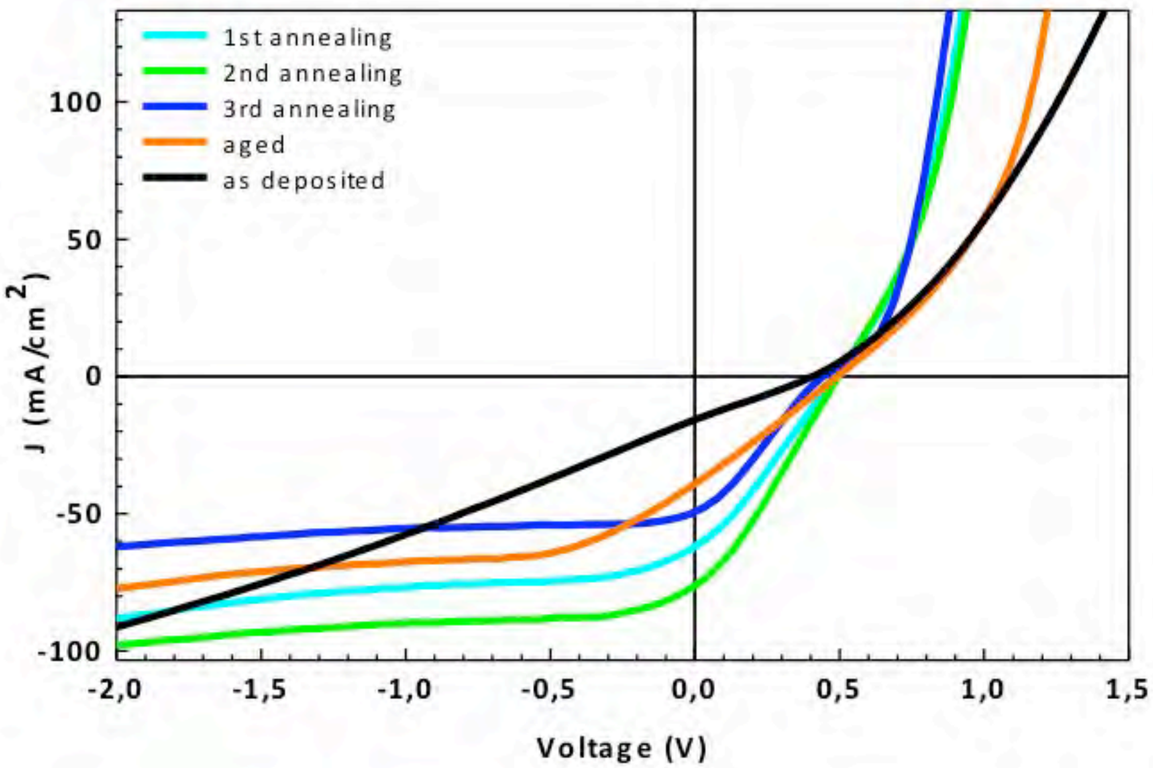
$$\eta = \frac{P_m}{E \times A_C} \approx 3\%$$

After annealing

Sample with R_S = 3.7 kΩ

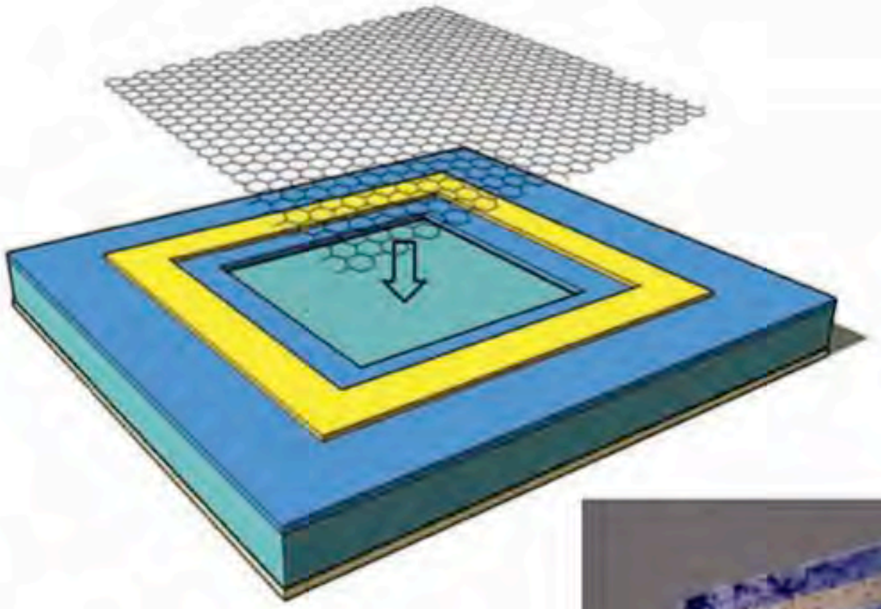
	R (kΩ)	R_{sheet}(kΩ)	FF	η (%)
As deposited	3.725	6.15	0.26	1.7
Aged (15 gg)	2.3	3.8	0.26	5.06
1st Ann. @ T=280°C	1.5	2.5	0.28	8.43
2nd Ann. @ T=280°C	1.36	2.2	0.29	10.73
3rd Ann. @ T=280°C	1.98	3.3	0.27	5.90

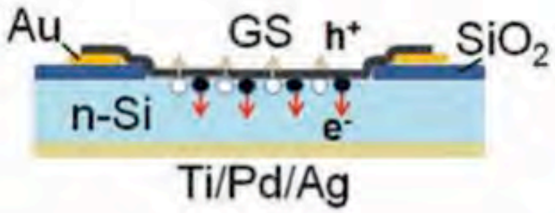


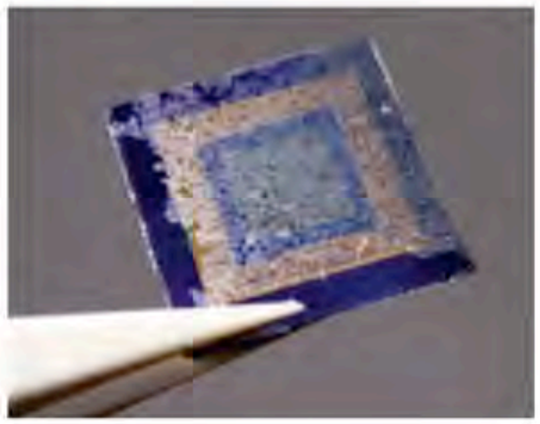


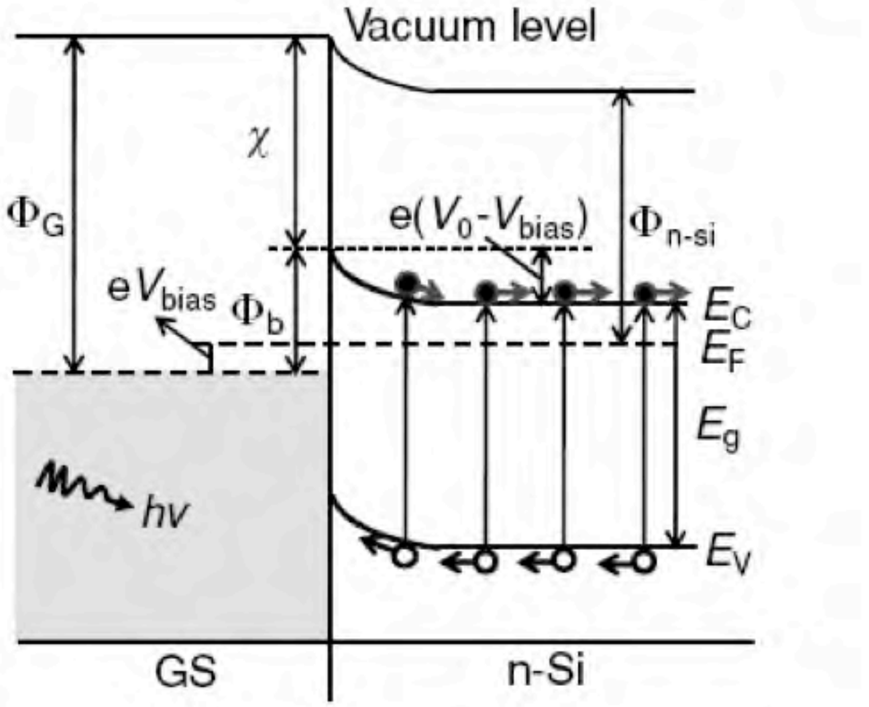
Graphene/Si solar cell

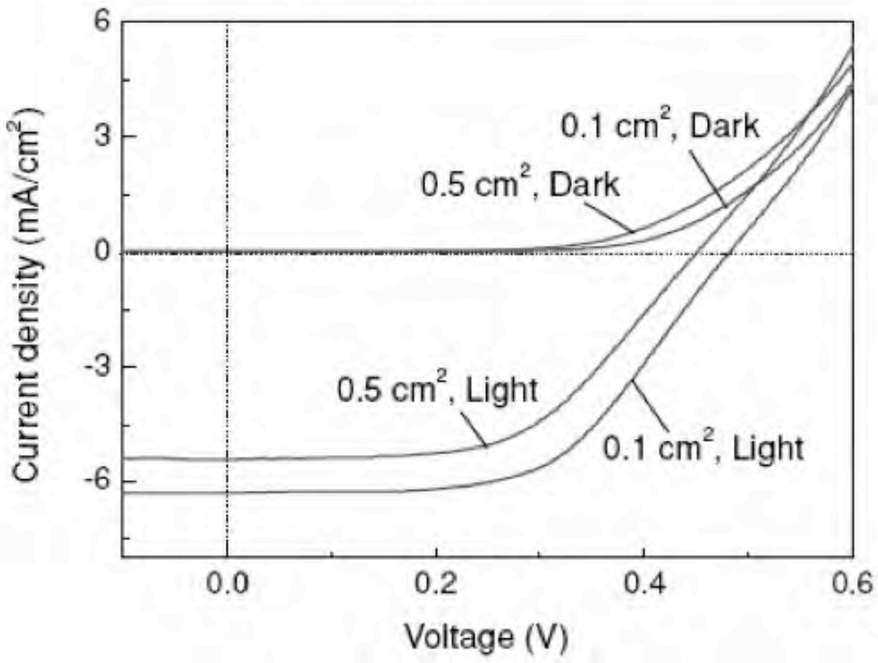
Schottky junction between metallic graphene and semiconducting Si





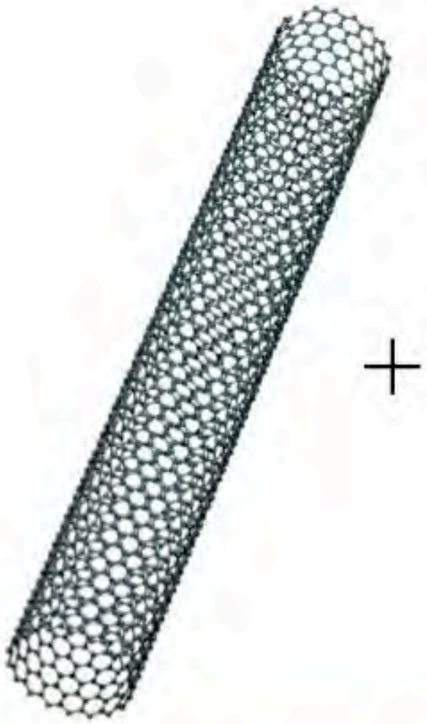




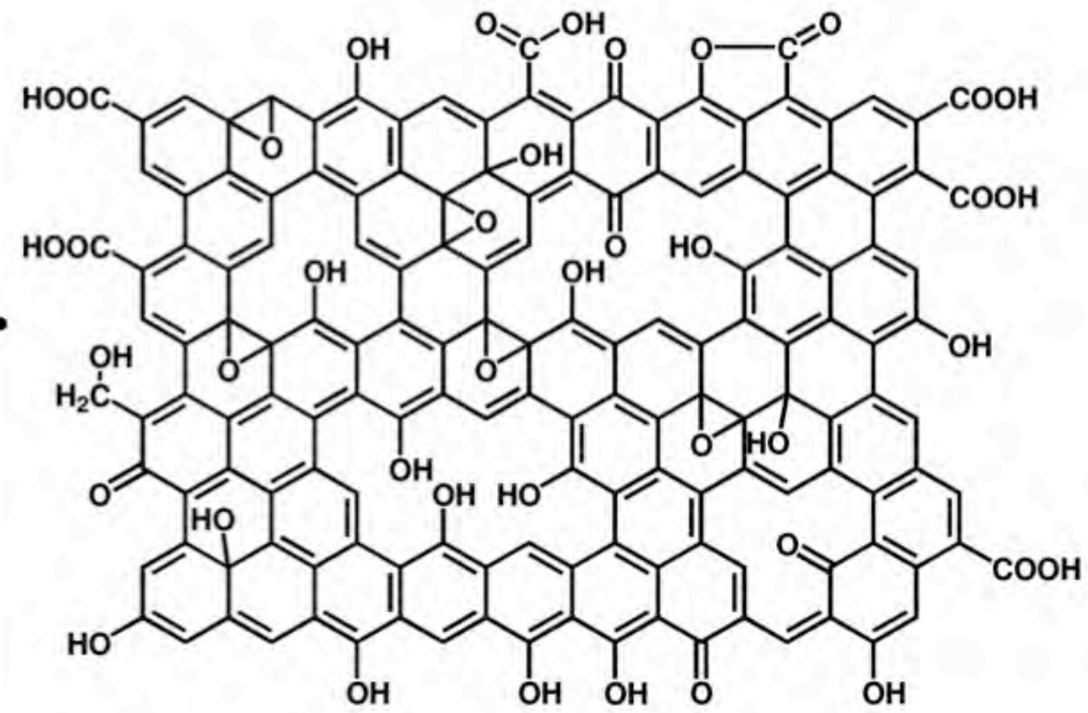


X. Li et al. *Adv. Mater.* 22 (2010) 2743

Synthesis of Graphene Oxide Nanoribbons (GONR)



$$+ KMnO_4 + H_2SO_4 \rightarrow$$

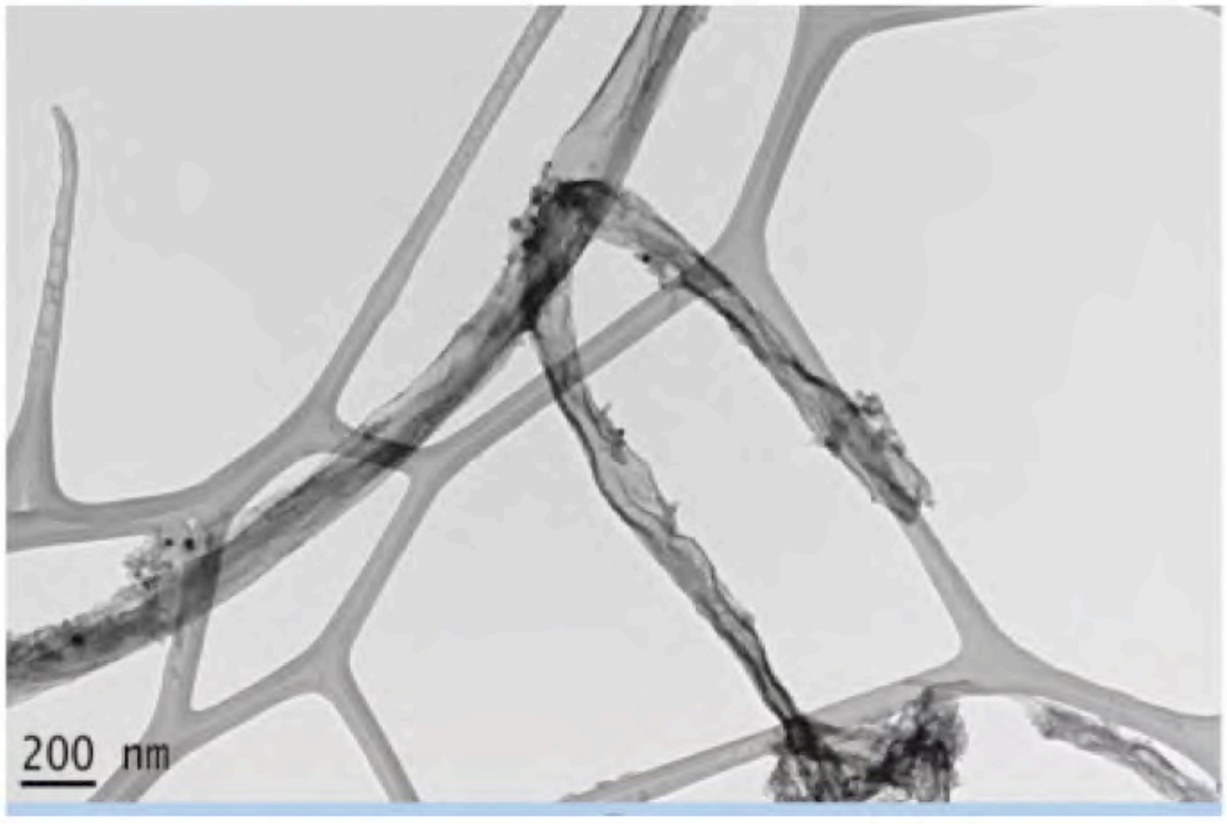


D.V. Kosynkin et al. Nature Lett. 458 (2009) 872

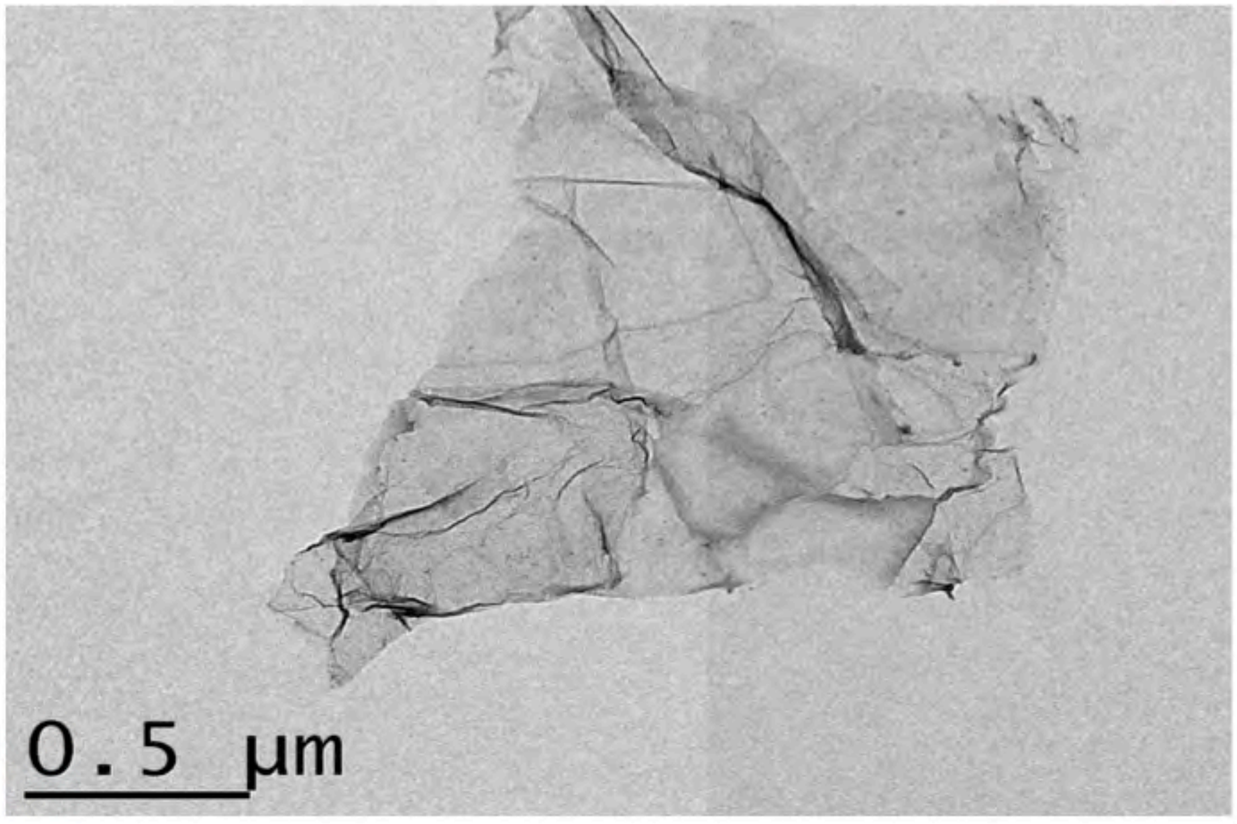
$$E_g = 2.8 - 4.2\,eV$$

J. A. Yan et al., Phys. Rev. Lett. 103 (2009) 086802

TEM images of GONR



Partially unzipped MWCNT



Warped Graphene sheet

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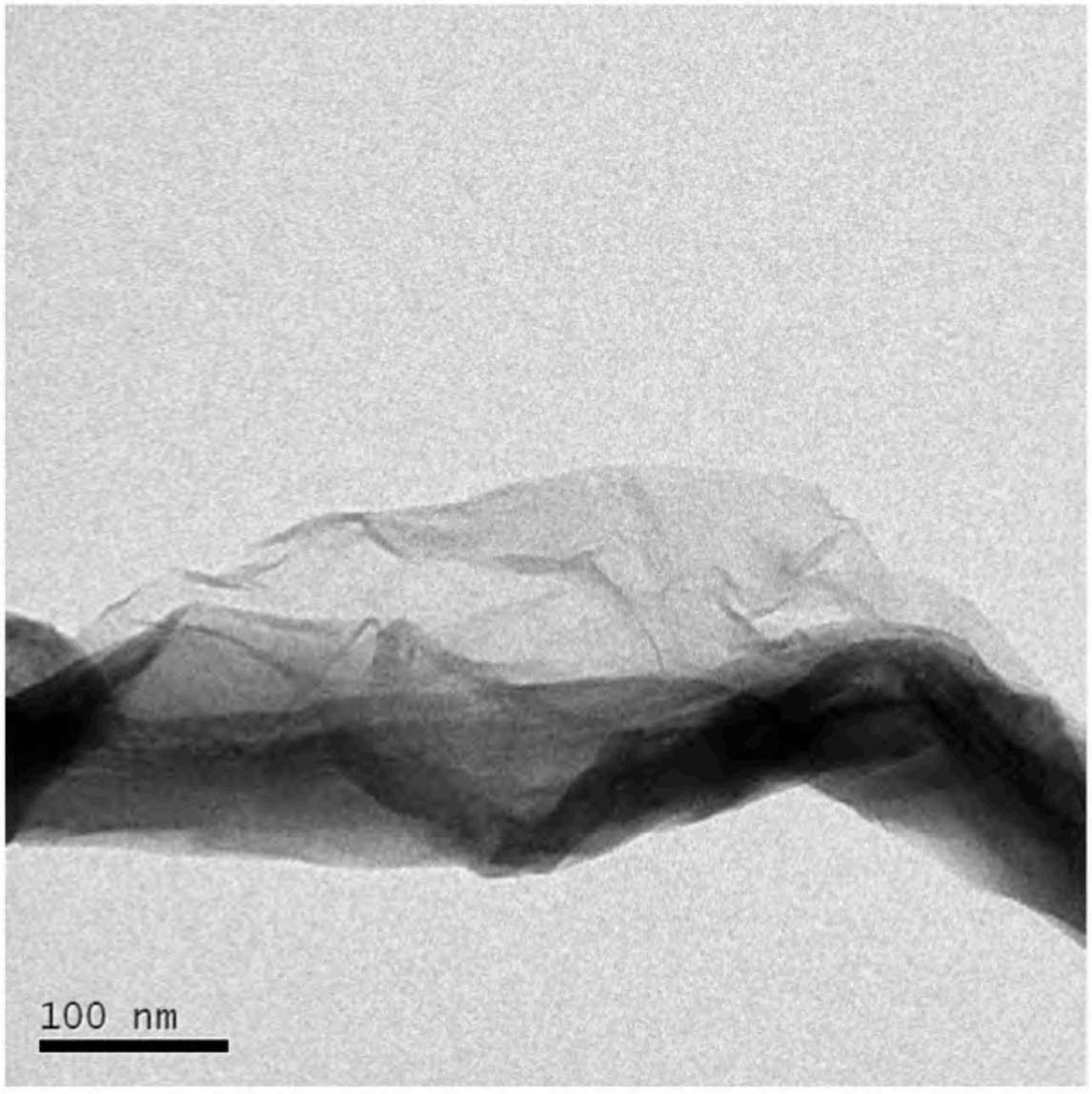
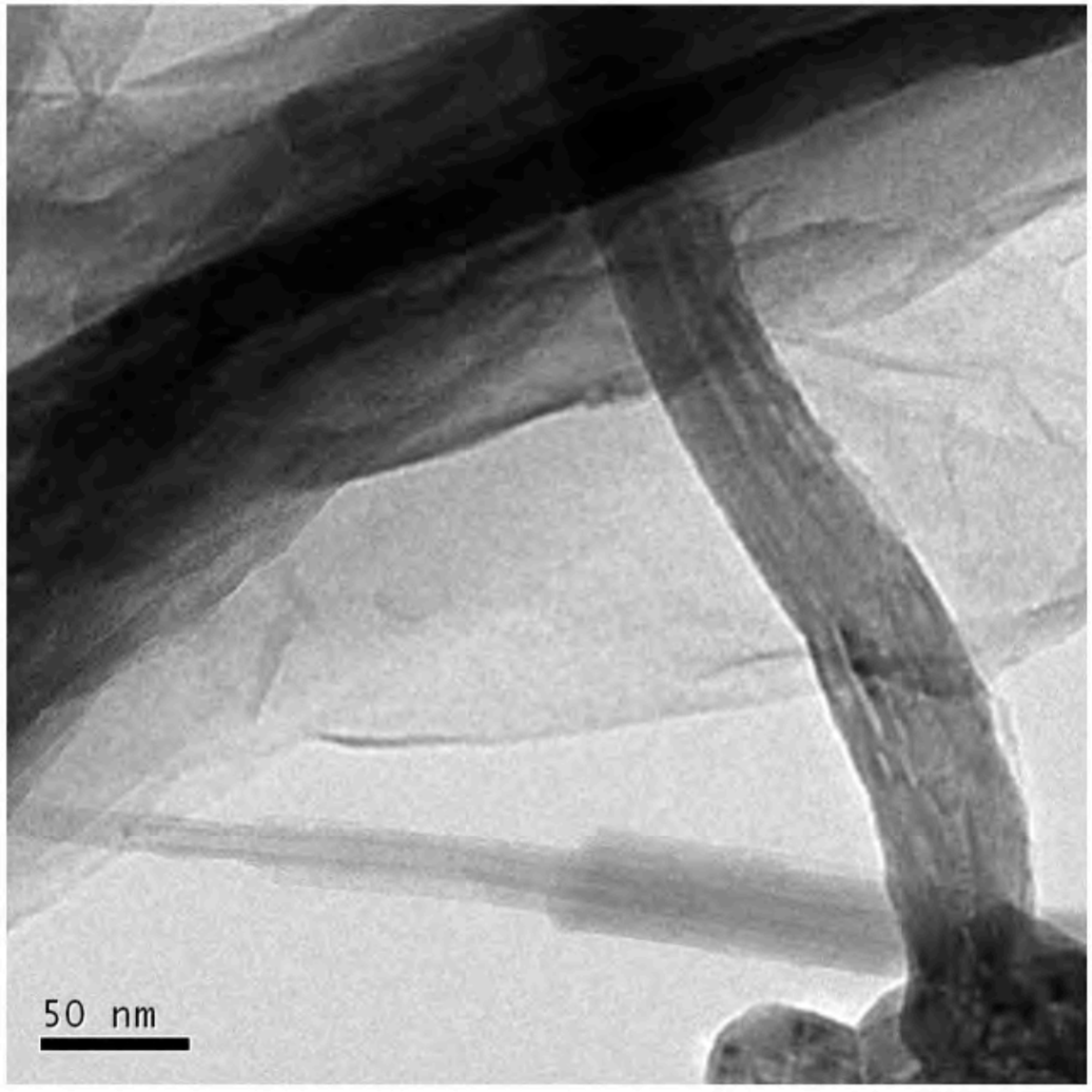




Partially peeled off carbon nanotubes

MWCNT/SWCNT deposition

Dispersion in N,N-Dimethylformamide (DMF) or o-dichlorobenzene (o-DCB) 1h in ultrasound bath (conc. 1-10 µg/ml)

Airbrush deposition on hot patterned Si substrates (200 °C)

GONR or MWCNT suspension in DMF or o-DCB

Patterned SiO_2/Si

Air brush

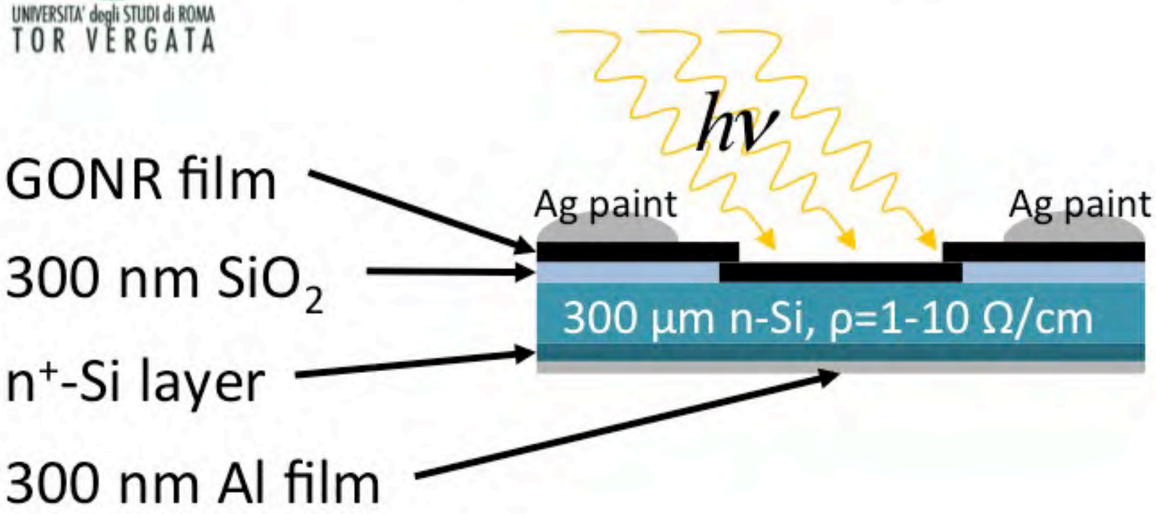
N_2 as gas carrier

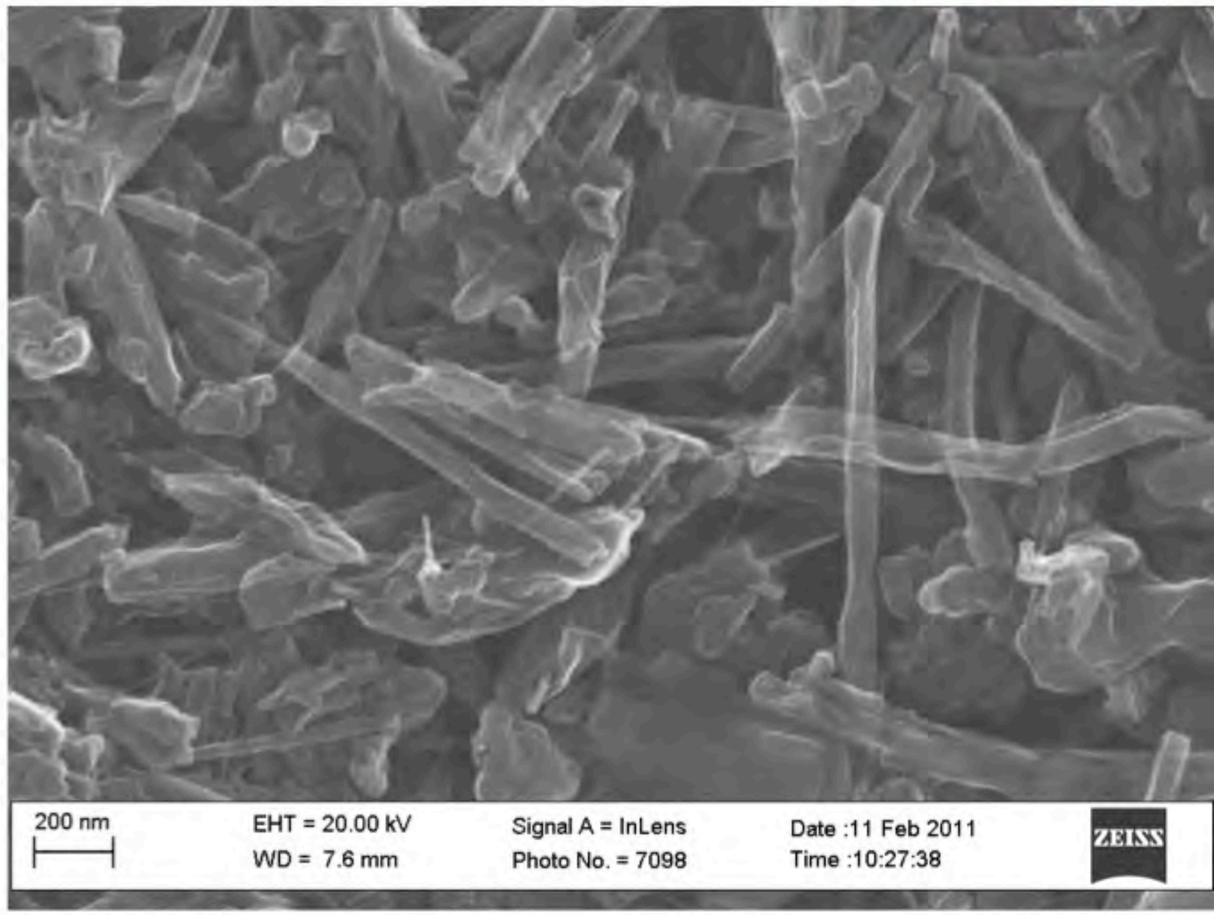
Hot support

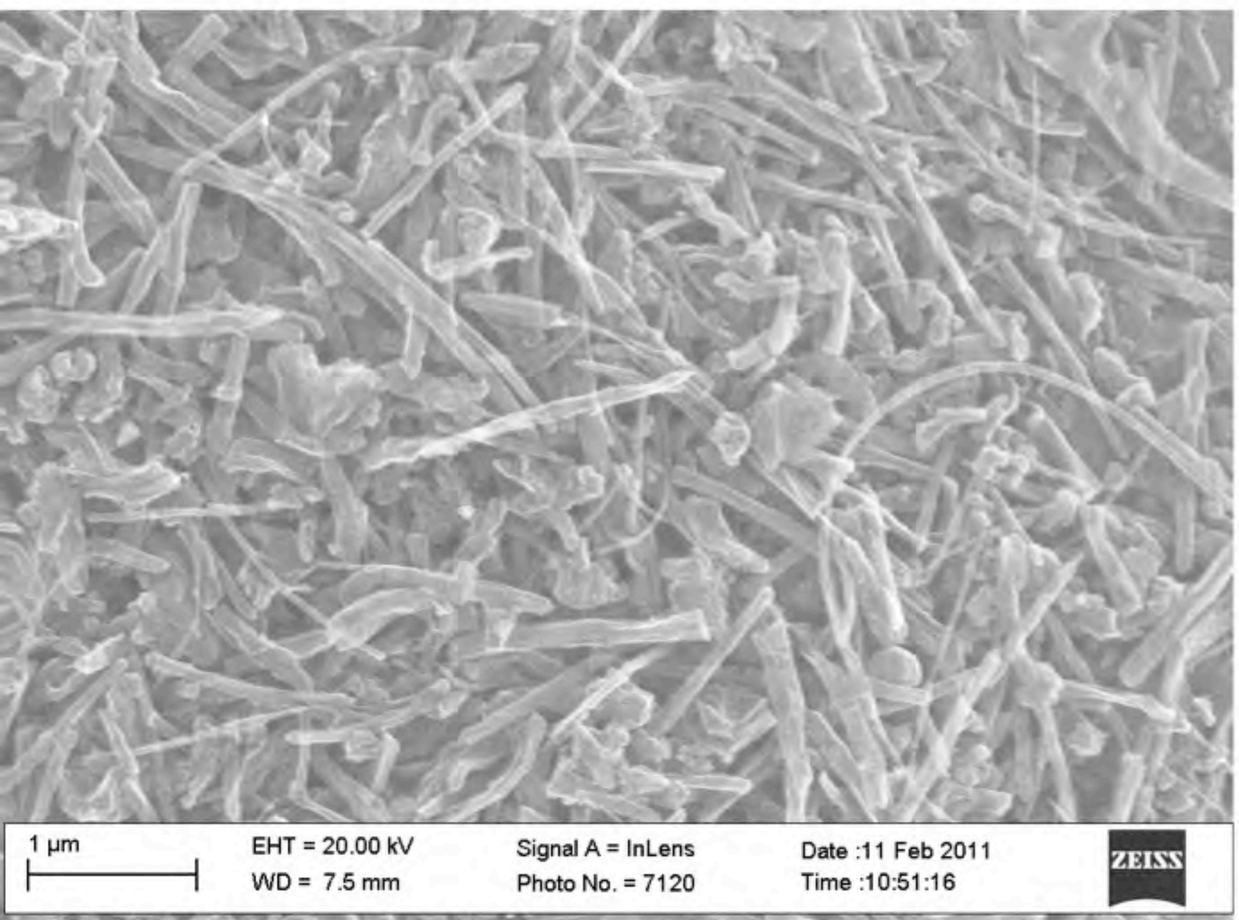
$$\theta_C \propto \frac{1}{R_S} = \frac{W}{L} R^{-1}$$

$$T\ ;\ 200\,^{\circ}C$$

SEM images of GONR films on Si







$$R_S = 0.8 - 1.0\,M\Omega$$

Optical setup

Lock-in amplifier

Labview interface

amplifier

Low noise amplifier

Si photodetector

Sample

Monochromator

Xe lamp

X,Y,Z stage

Mirrored chopper

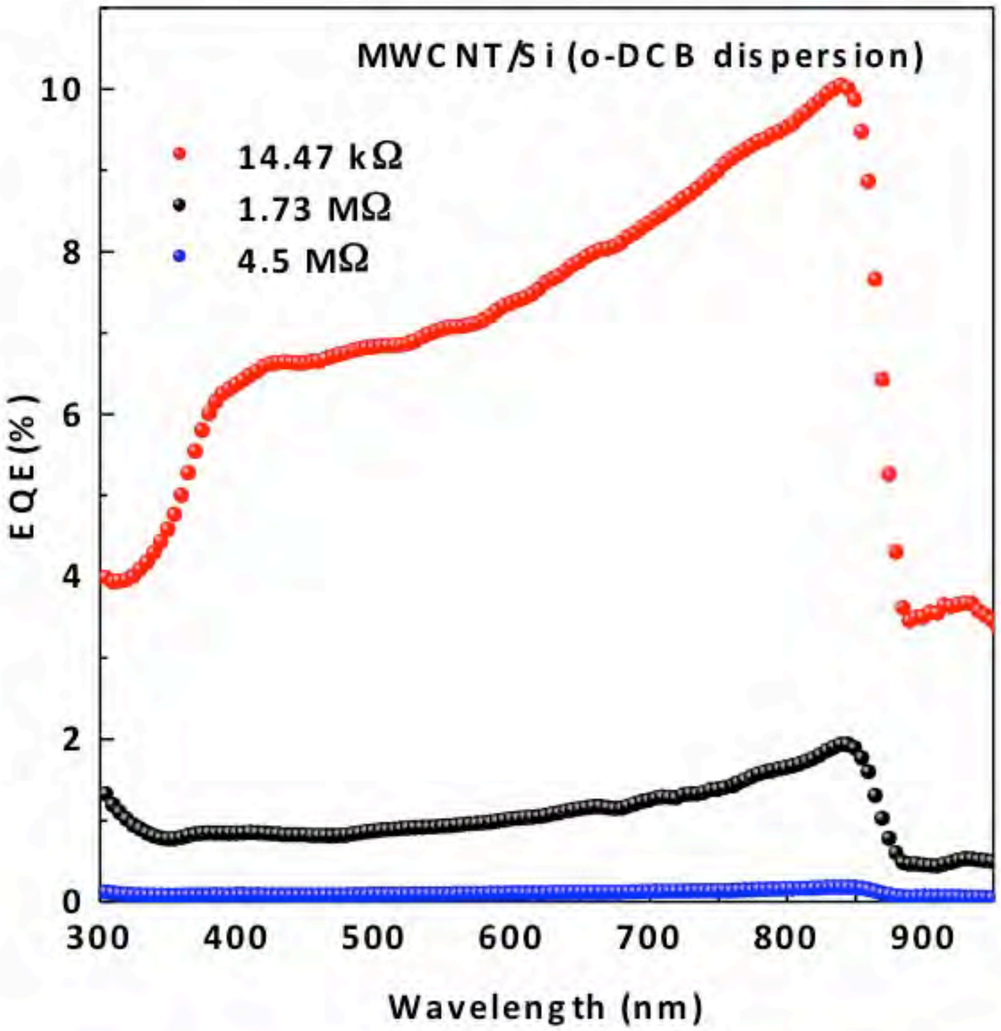
PC interface

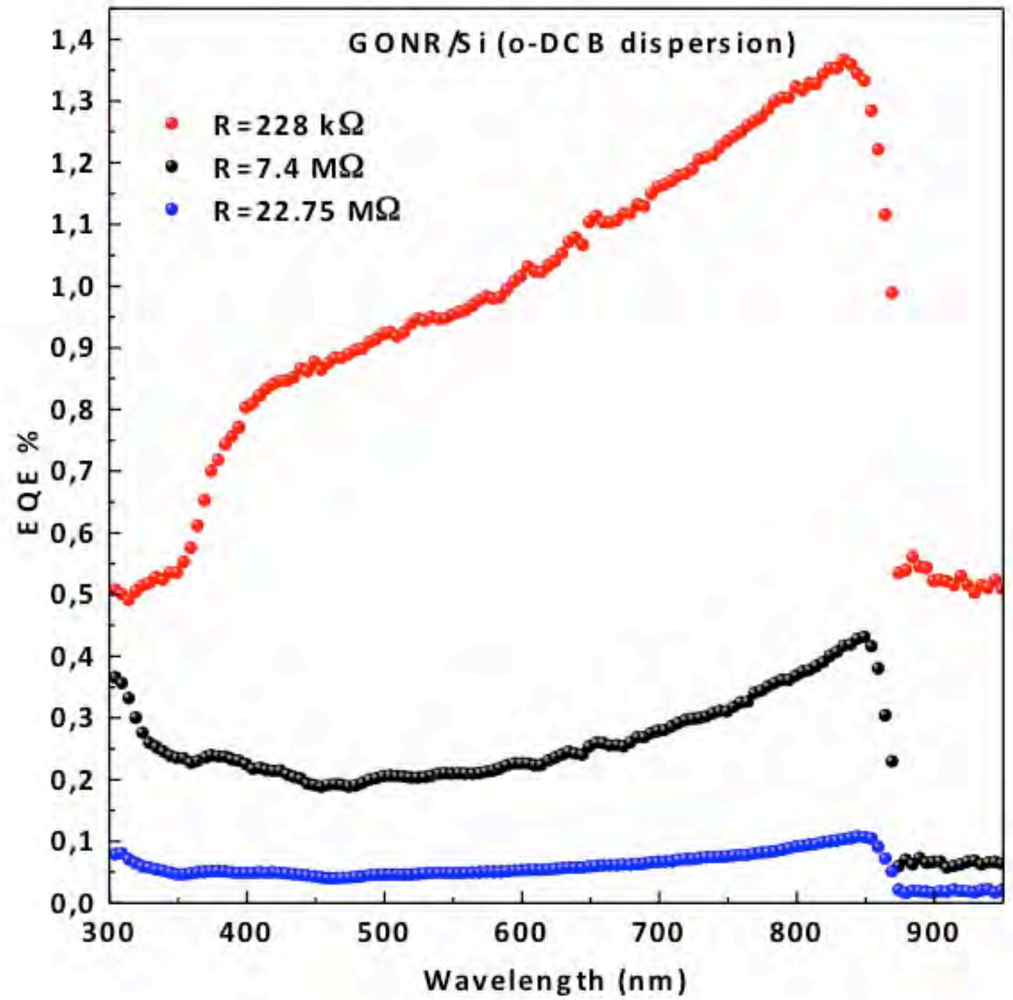
Sourcemeter

External quantum efficiency

$$EQE(\lambda) = \frac{hcI(\lambda)}{e\lambda P(\lambda)} 100$$

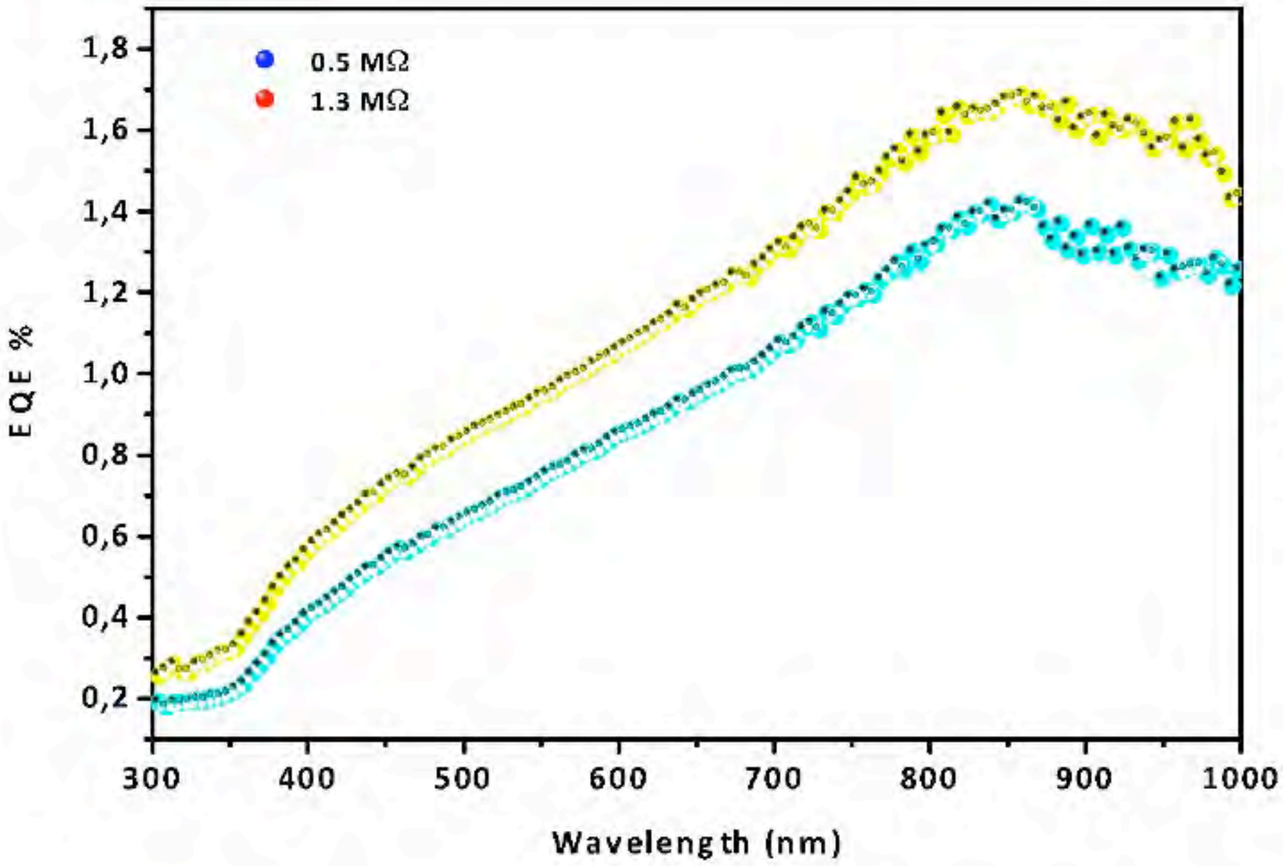
Optoelectronic characterization

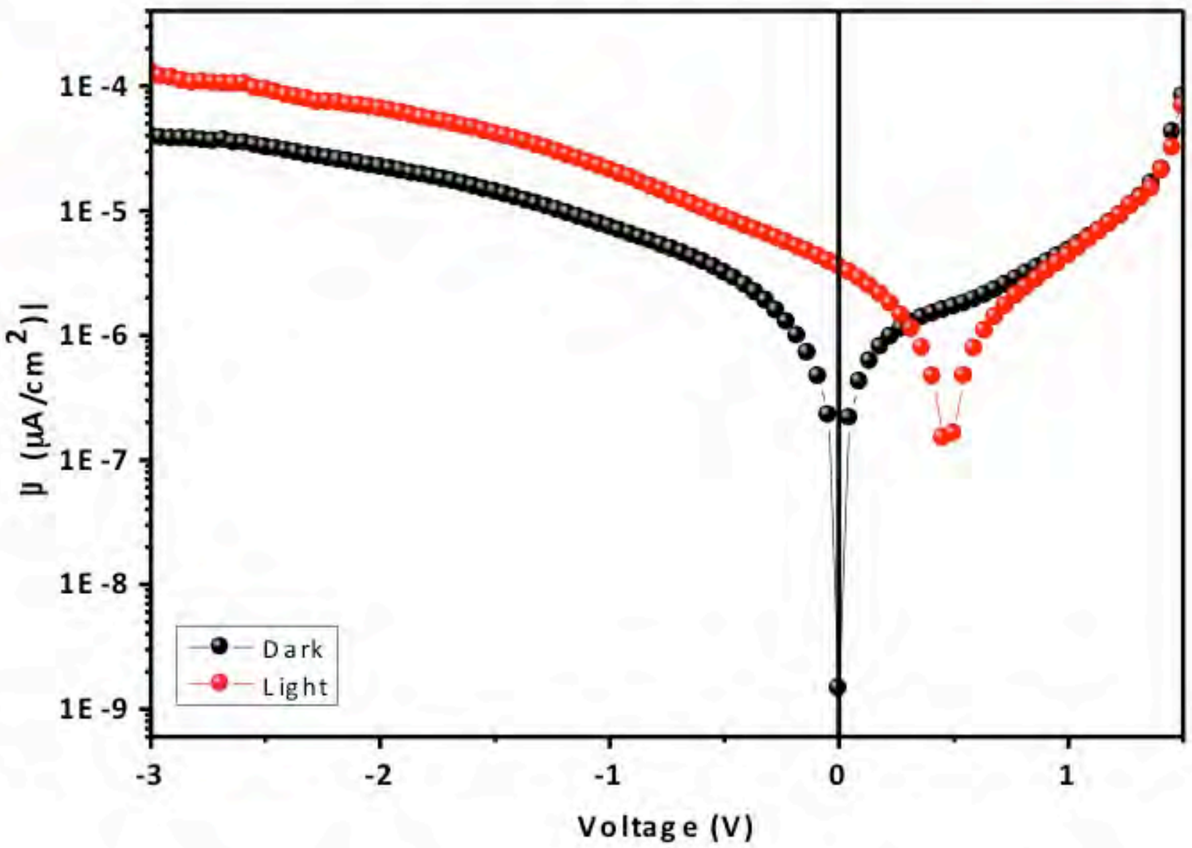




Samples prepared from o-dichlorobenzene GONR and MWCNT suspensions

Optoelectronic characterization





$$EQE(\lambda) = \frac{hcI(\lambda)}{e\lambda P(\lambda)}100$$

$$I_{SC} \approx 10^{-6}\ \mathrm{A}$$

$$V_{0C} \approx 500\ \mathrm{mV}$$

Samples prepared from N,N-dimethylformamide GONR and MWCNT suspensions

Summary

- Graphenic nanoribbons were produced by chemical unzipping of MWCNTs
- Photovoltaic devices were realized depositing GONR and MWCNT films on Si
- Low conductivity of the GONR films negatively affects the efficiency of the cells
- Improvements of the GONR films are needed

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Thank you for attention!