Photocurrent measurement in thin-film single-walled carbon nanotube field-effect transistors

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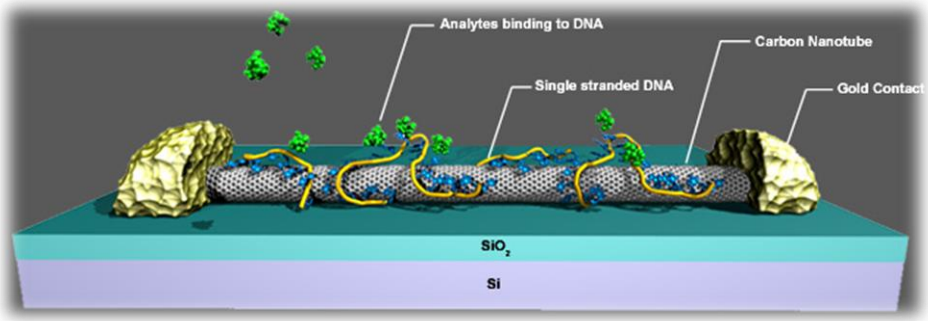
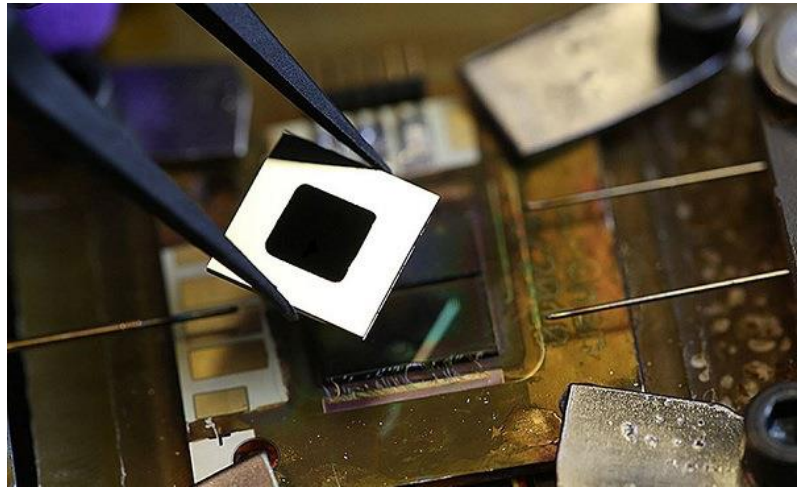


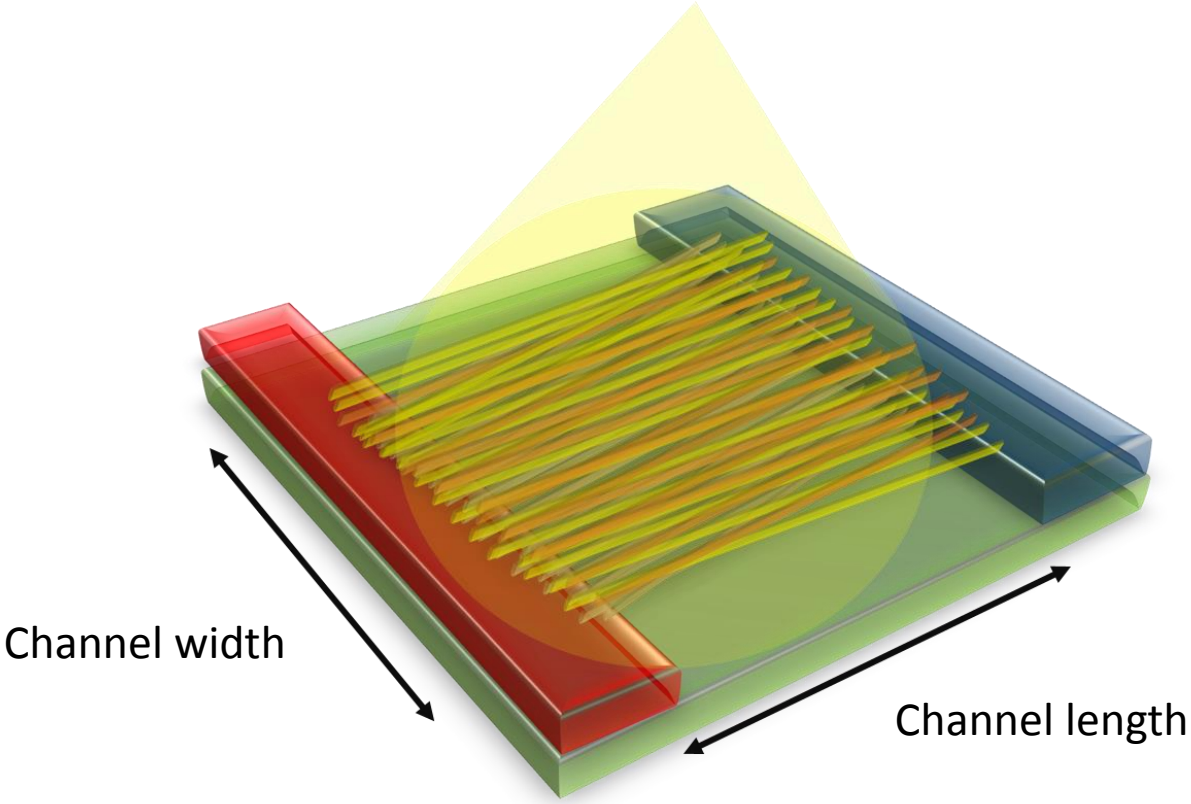
http://carbonnanotubestech.com/carbon-nanotubes/dna-functionalized-carbon-nanotube-chemical-sensors

http://news.filehippo.com/2013/09/carbon-nanotube-computer-technology-breakthrough/

INTRODUCTION



http://www.techtimes.com/articles/2813/20140120/mit-develops-hot-carbon-nanotubes-that-lets-solar-panels-draw-more-sun.htm

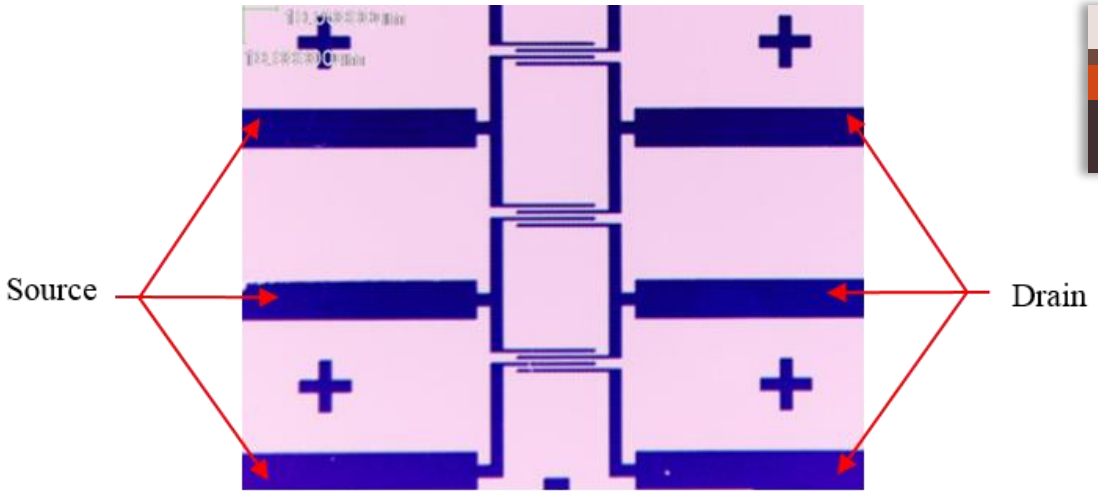


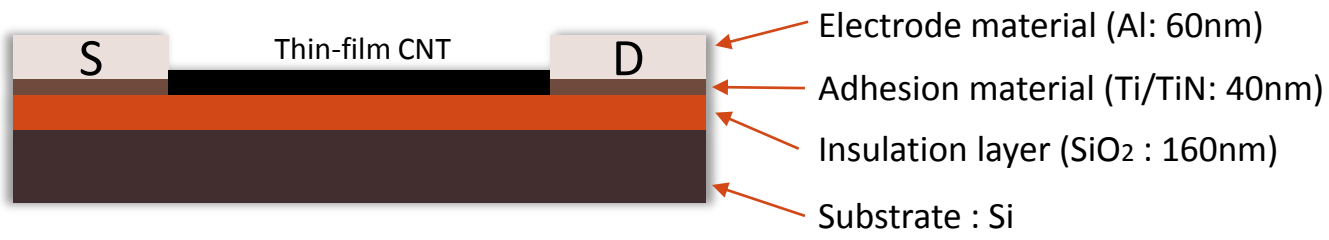
OBJECTIVES

- Fabricate single-walled carbon nanotube thin film for a field-effect transistor device by a solution process technique using dielectrophoresis (DEP) method
- Study electrical transport characteristics of the device prepared in Objective 1 with a single conducting channel and dual conducting channel schemes at room temperature under broadwavelength (200-2500 nm) light illumination

EXPERIMENT

ELECTRODE STRUCTURES

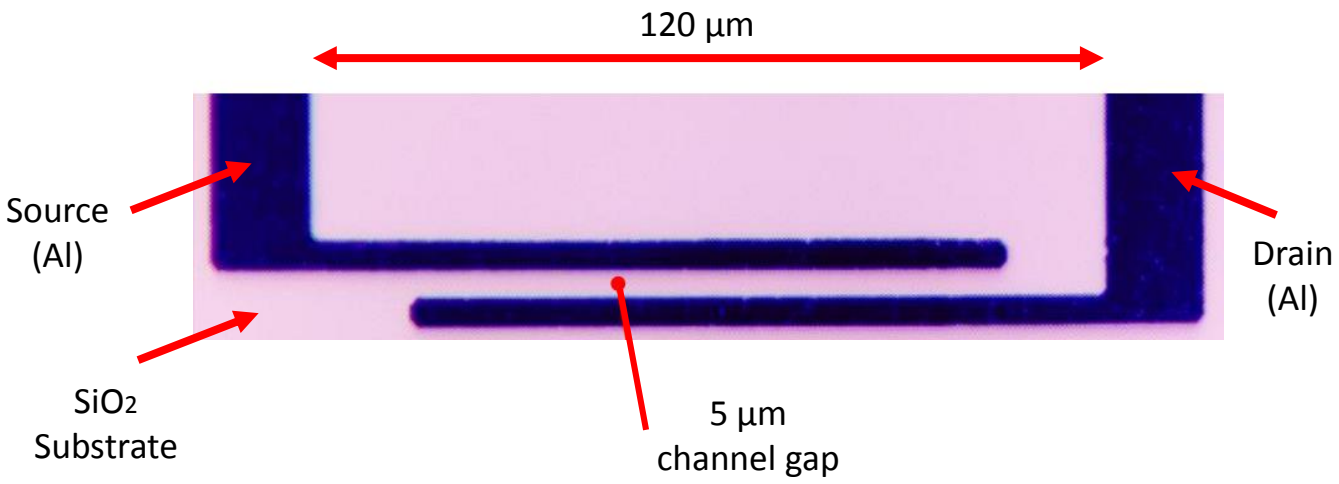




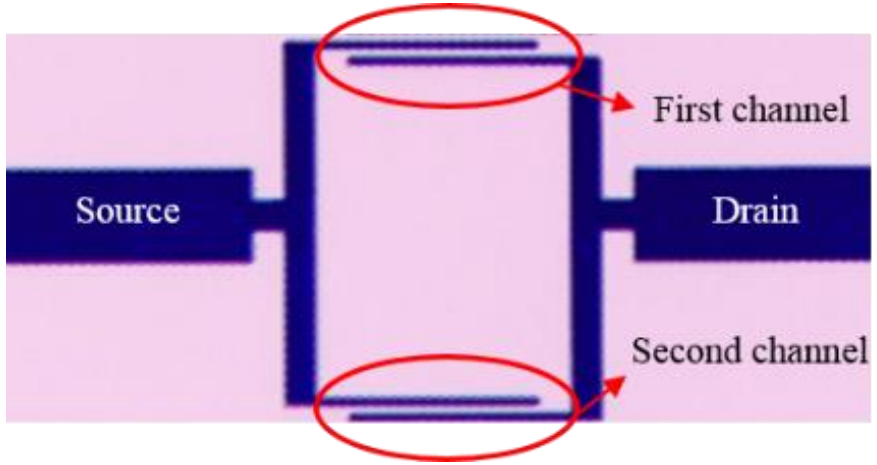
TMEC
Thai Microelectronics Center

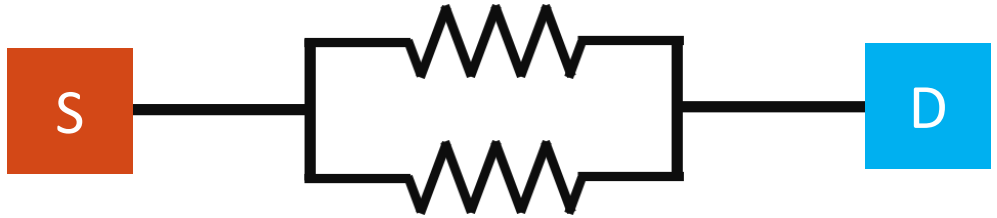
ELECTRODE STRUCTURES

Top view of single conductive channel

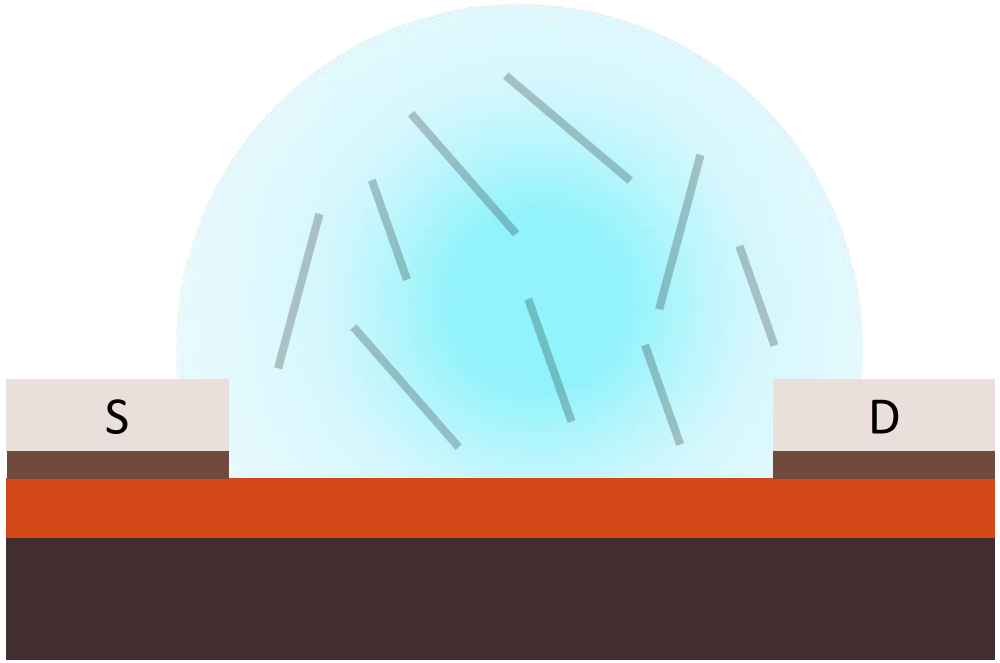


Top view of parallel conductive channel





FABRICATION



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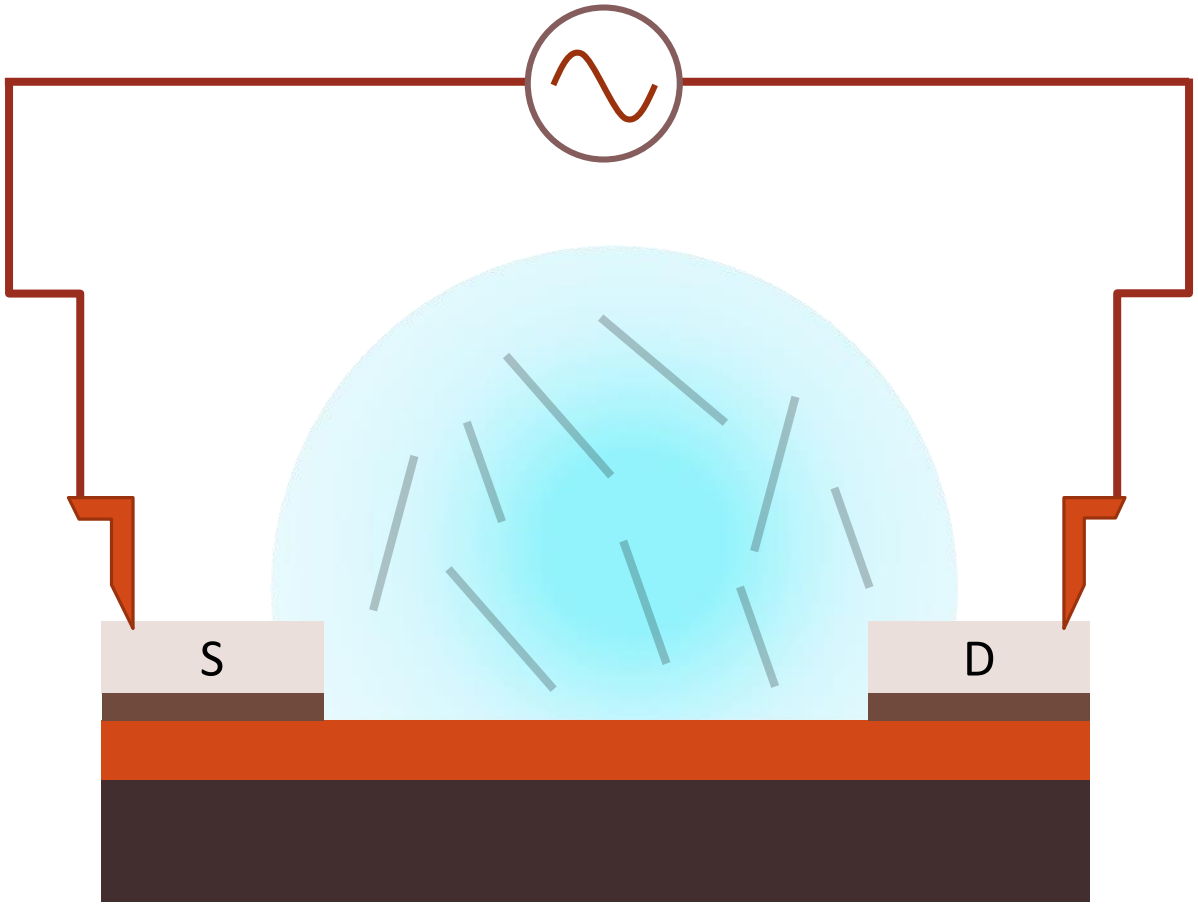
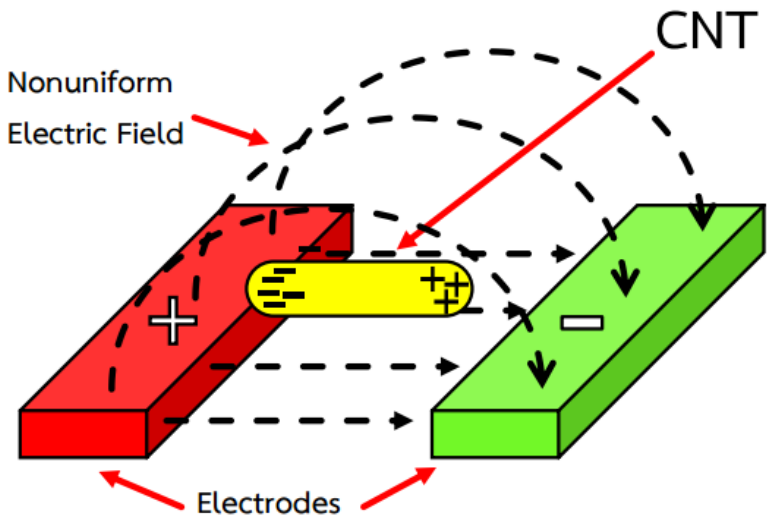




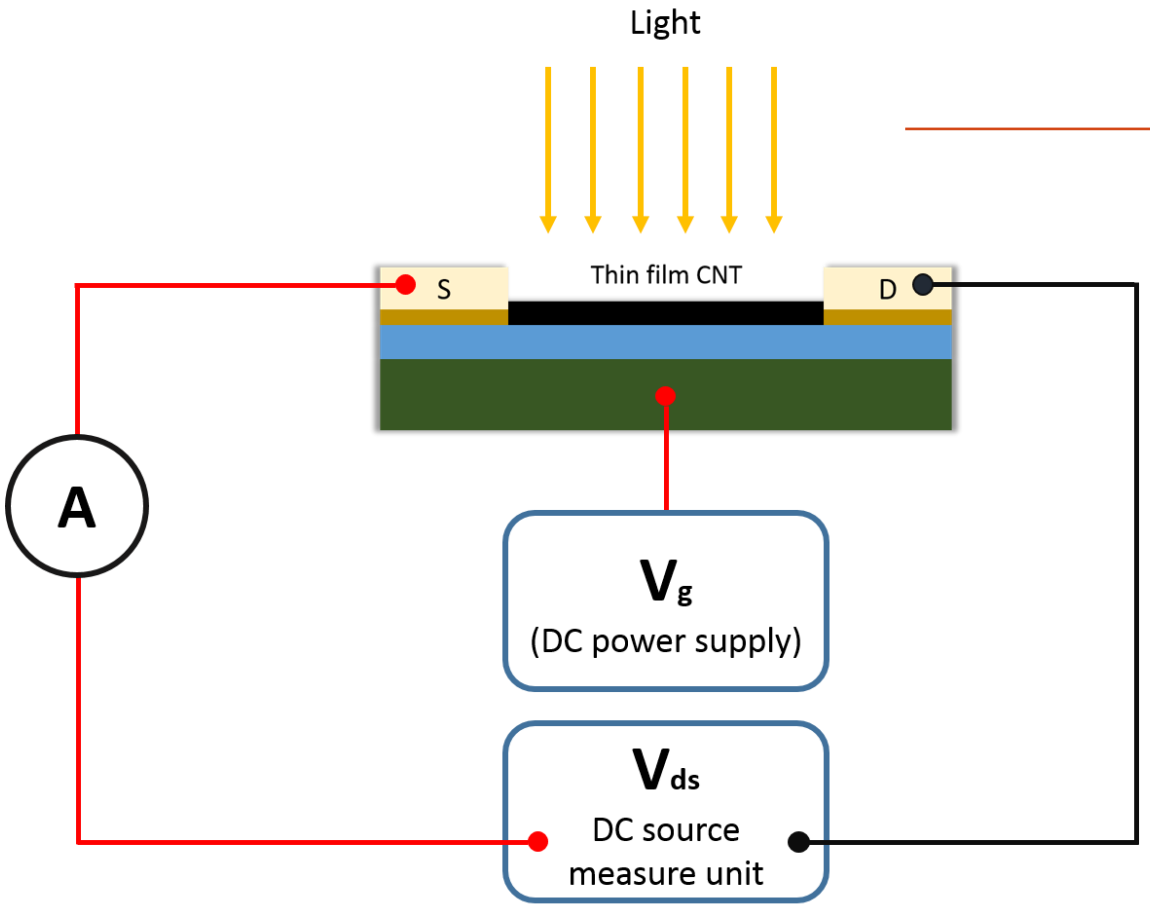
$$\vec{F}_{DEP} = 2\pi r^3 \varepsilon_m \operatorname{Re}[K^*(\omega)]\vec{\nabla}|\vec{E}|^2$$

ε_m is electric permittivity of medium

$K^*(\omega)$ is Clausius-Mossotti coefficient

$\vec{\nabla}|\vec{E}|^2$ is gradient of electric field strength

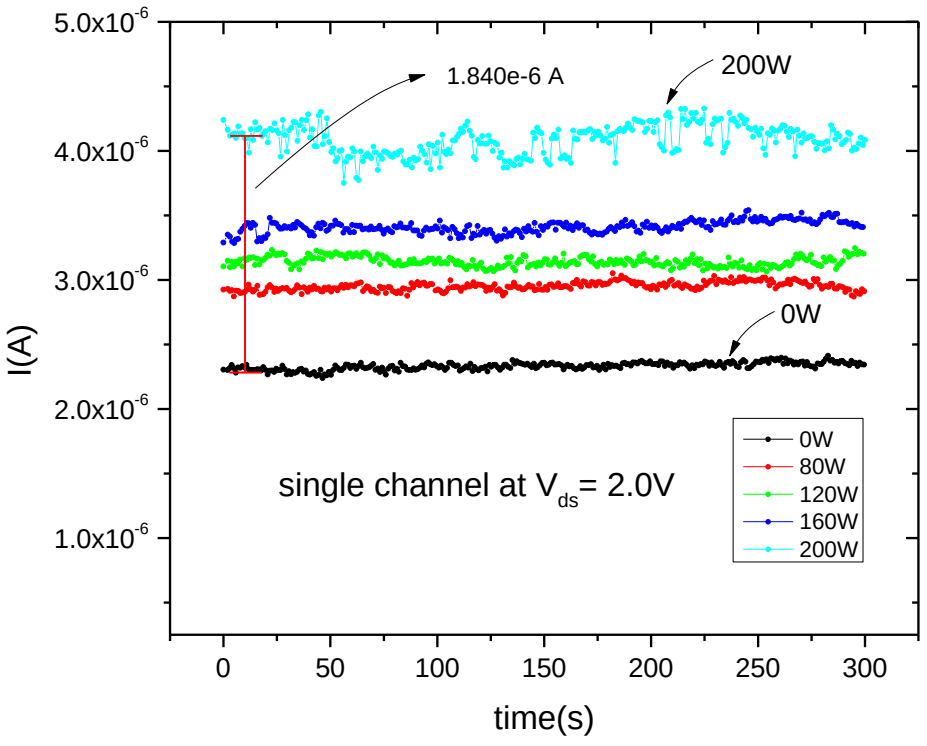
MEASUREMENT SETUP

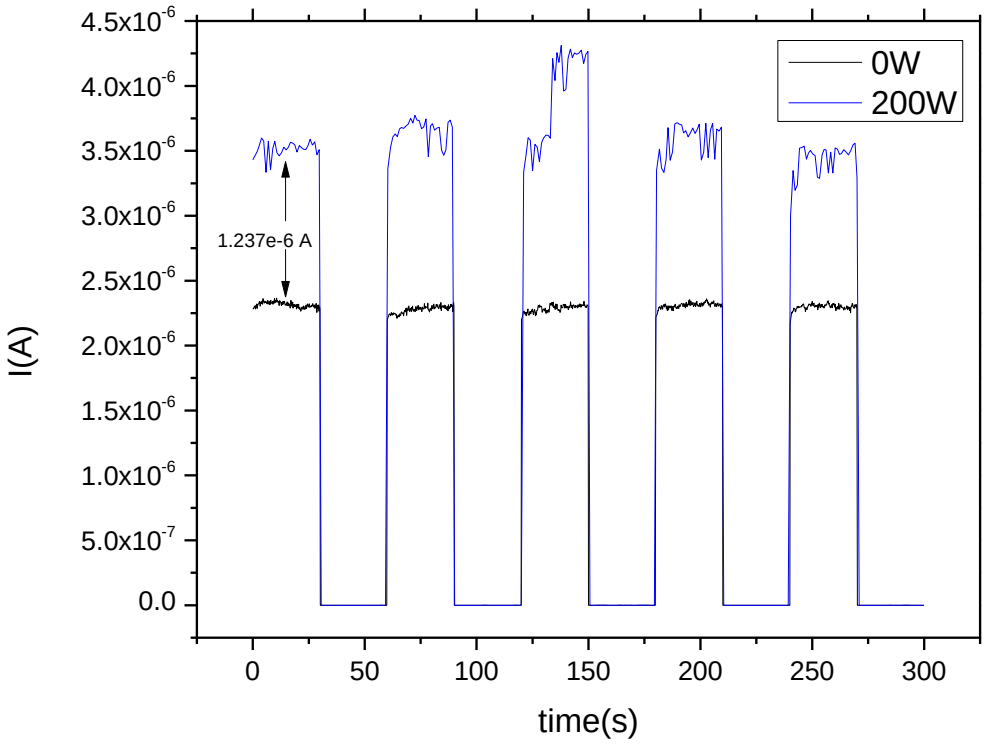


Broad wavelength 200-2500nm
Power mode = 0W-250W

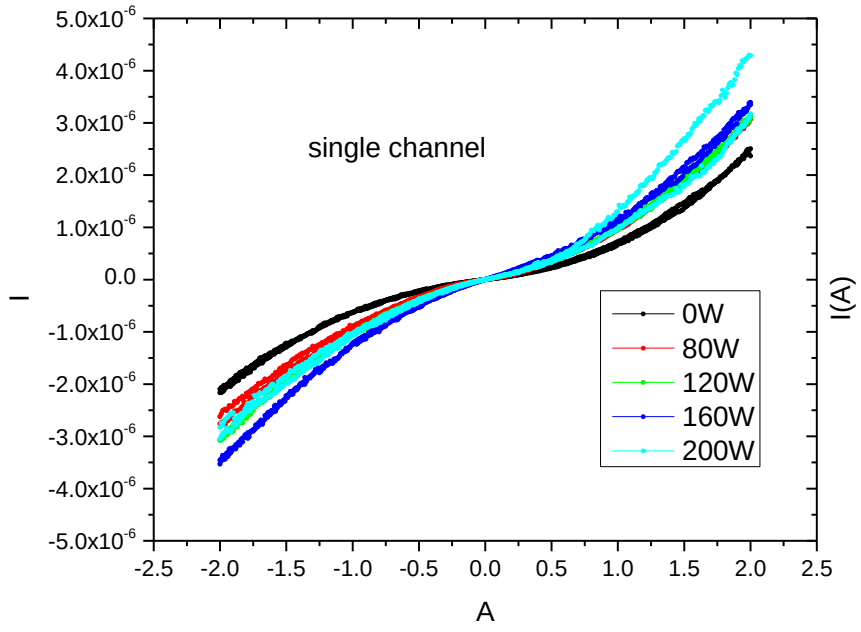
RESULTS AND DISCUSSION

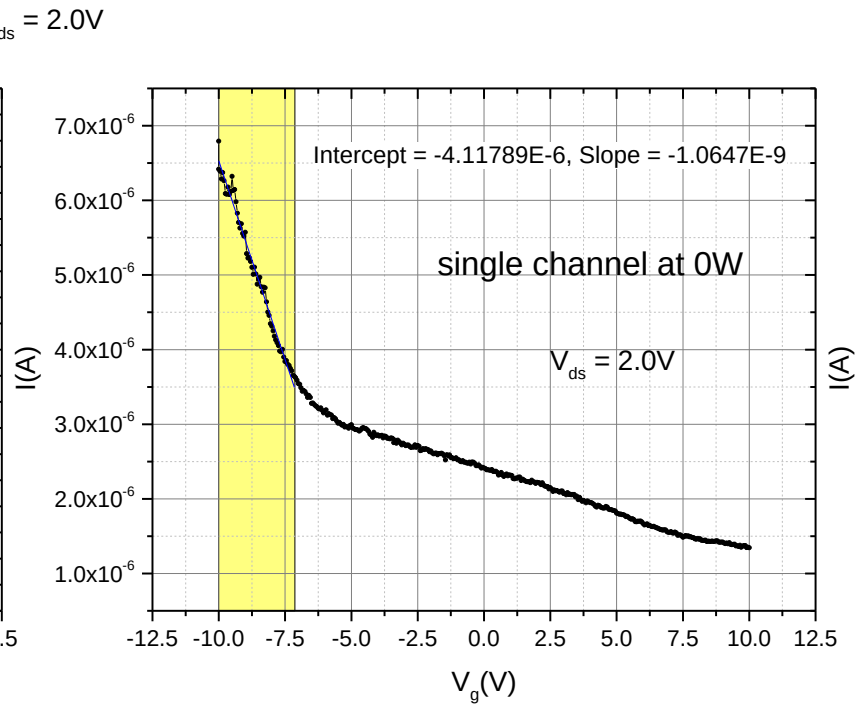
ELECTRICAL TRANSPORT (single-channel)

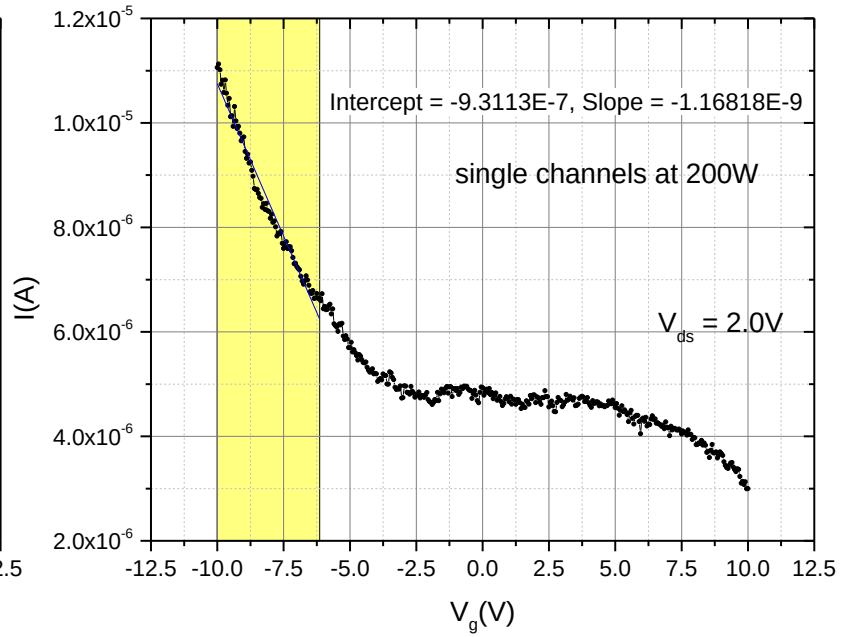




ELECTRICAL TRANSPORT (single-channel)





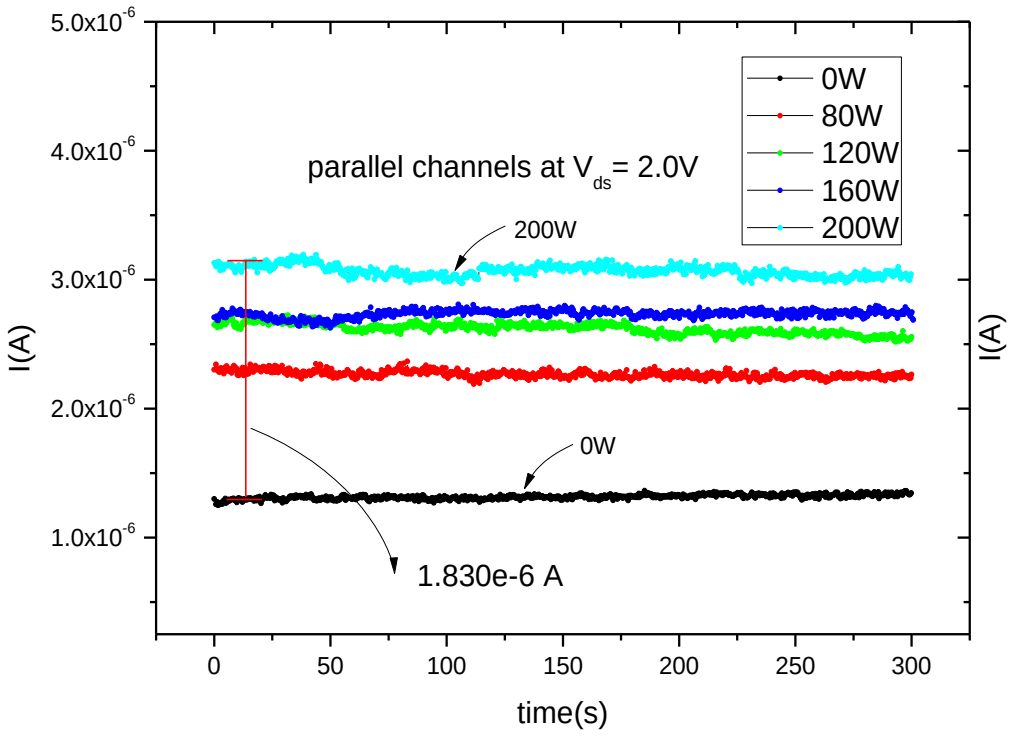


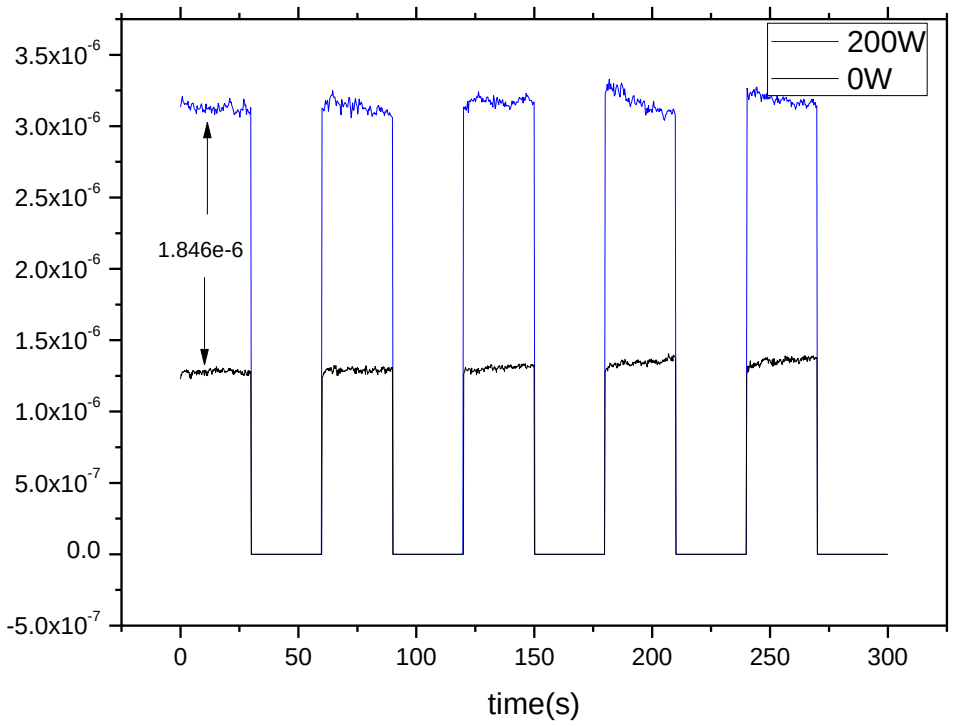
Mobility ∝ Trans-conductance

Trans-conductance = 1.064 µS

Trans-conductance = 1.168 µS

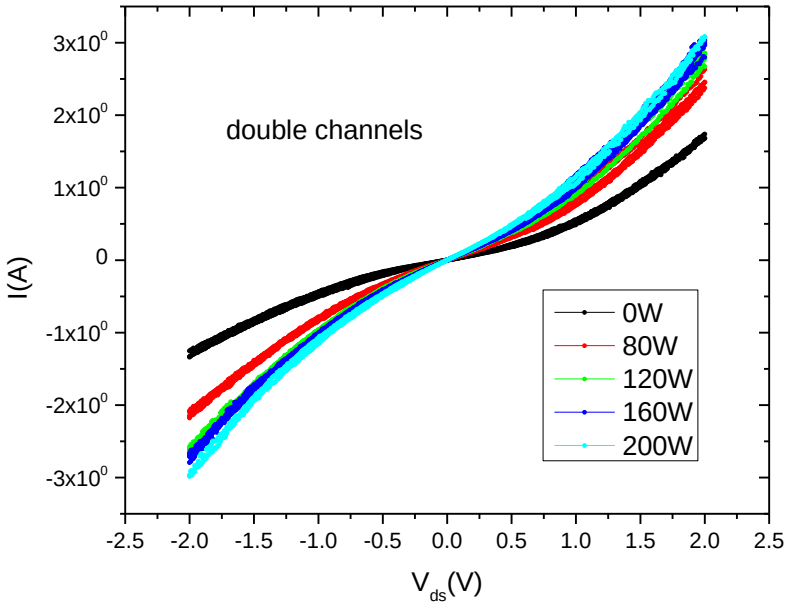
ELECTRICAL TRANSPORT (parallel channels)



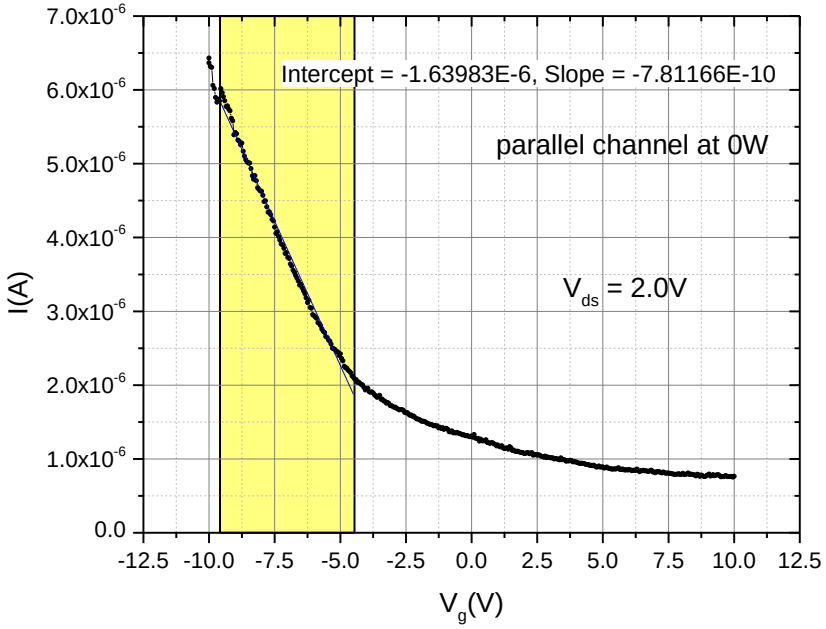


Measured current of parallel conductive channels is not equal to 2x of single conductive channel

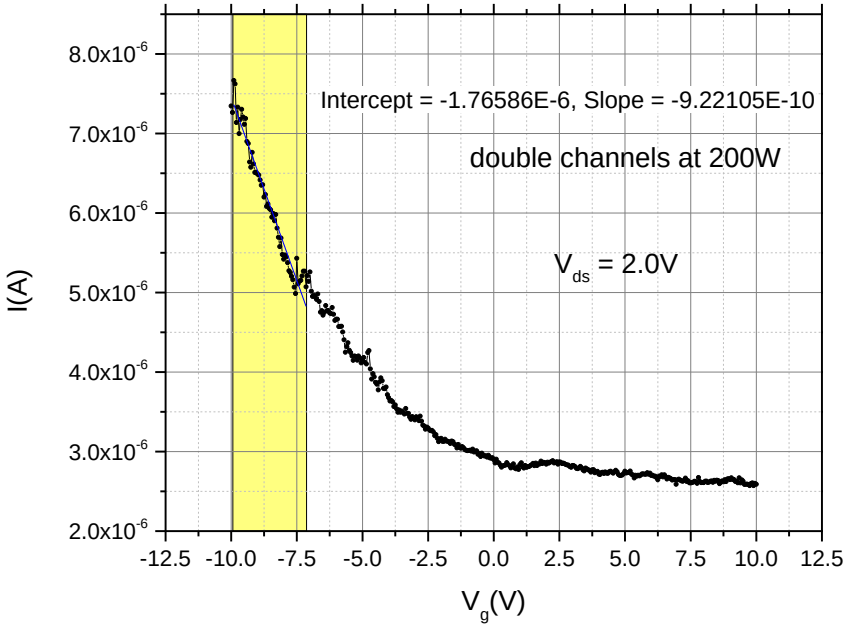
ELECTRICAL TRANSPORT (parallel channels)



Mobility ∝ Trans-conductance

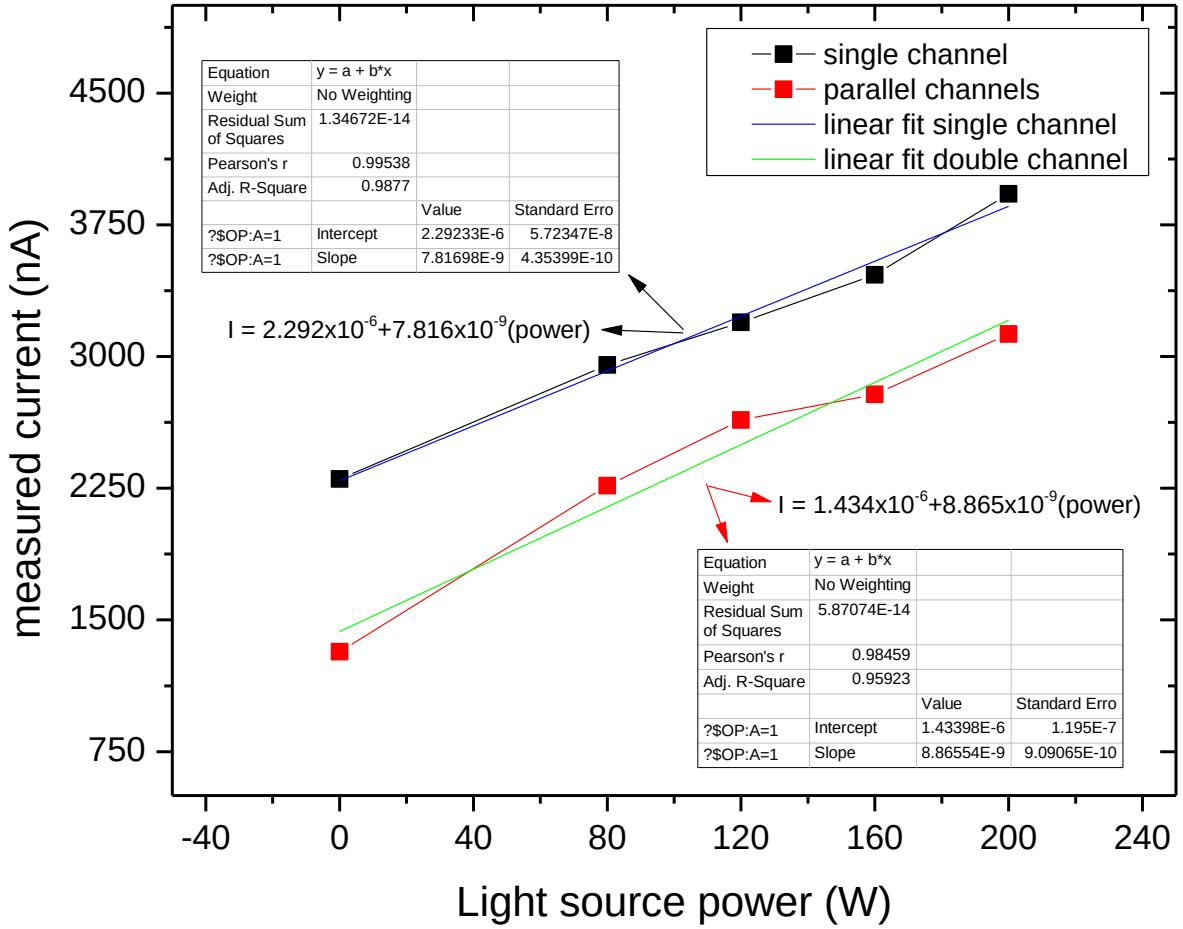


Trans-conductance = 0.781 µS



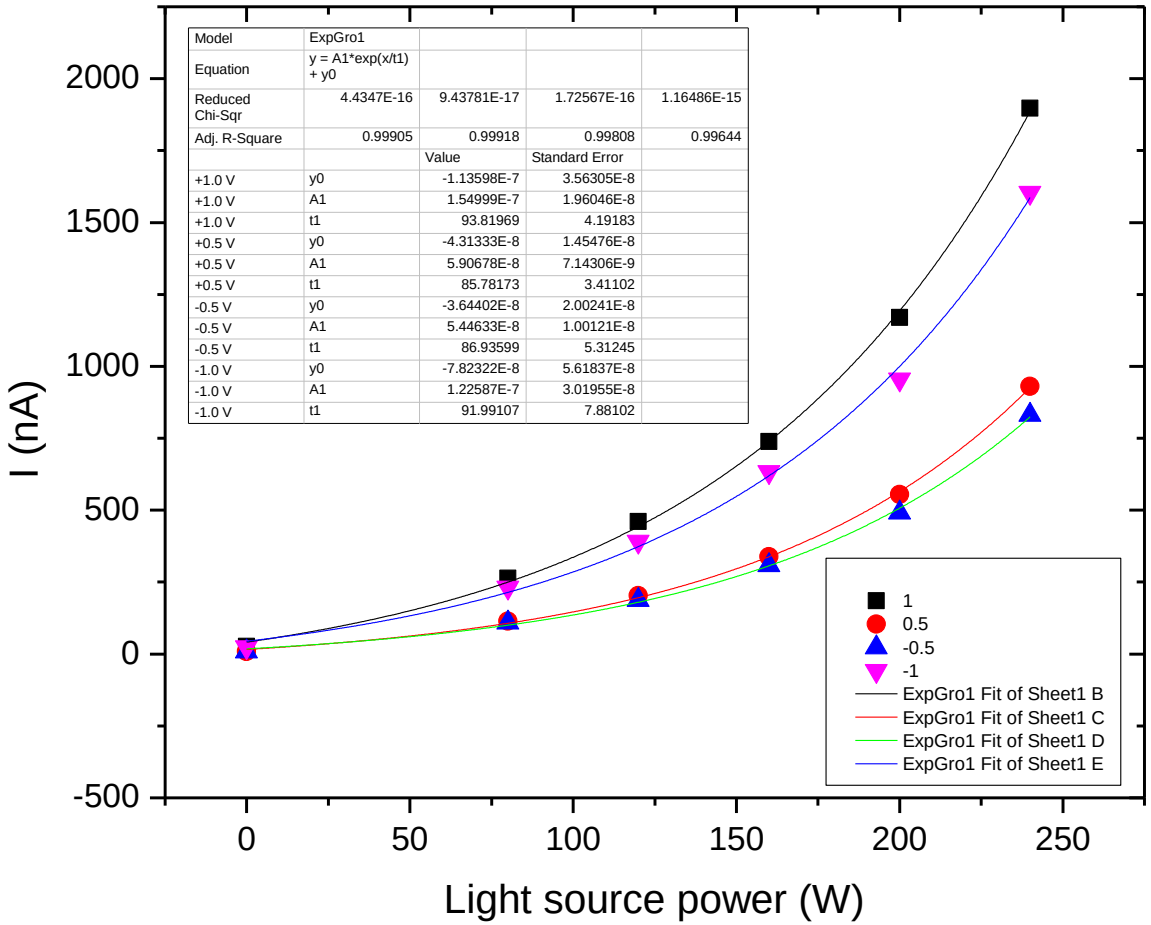
Trans-conductance = 0.922 µS

ELECTRICAL TRANSPORT



Equation	y = a + b*x		
Weight	No Weighting		
Residual Sum of Squares	1.34672E-14		
Pearson's r	0.99538		
Adj. R-Square	0.9877		
		Value	Standard Erro
?$OP:A=1	Intercept	2.29233E-6	5.72347E-8
?$OP:A=1	Slope	7.81698E-9	4.35399E-10

Equation	y = a + b*x		
Weight	No Weighting		
Residual Sum of Squares	5.87074E-14		
Pearson's r	0.98459		
Adj. R-Square	0.95923		
		Value	Standard Erro
?$OP:A=1	Intercept	1.43398E-6	1.195E-7
?$OP:A=1	Slope	8.86554E-9	9.09065E-10

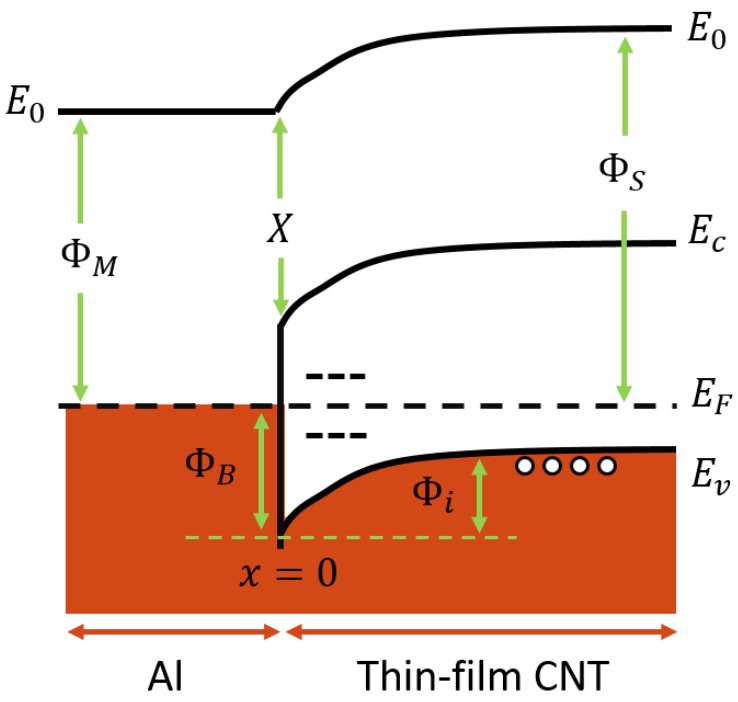


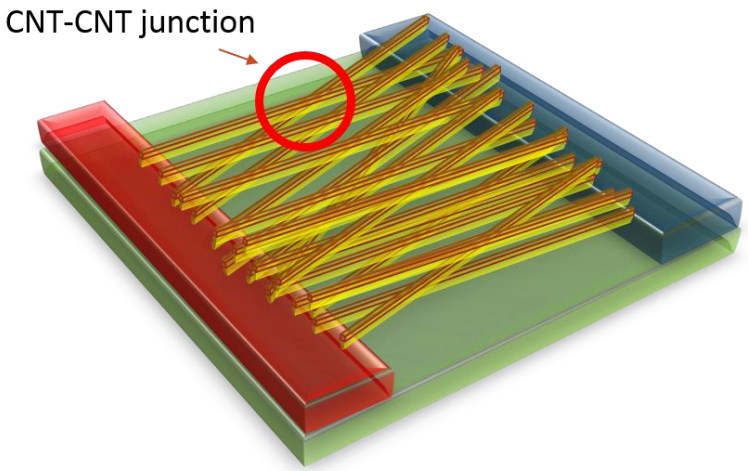
Model	ExpGro1			
Equation	y = A1*exp(x/t1) + y0			
Reduced Chi-Sqr	4.4347E-16	9.43781E-17	1.72567E-16	1.16486E-15
Adj. R-Square	0.99905	0.99918	0.99808	0.99644
		Value	Standard Error	
+1.0 V	y0	-1.13598E-7	3.56305E-8	
+1.0 V	A1	1.54999E-7	1.96046E-8	
+1.0 V	t1	93.81969	4.19183	
+0.5 V	y0	-4.31333E-8	1.45476E-8	
+0.5 V	A1	5.90678E-8	7.14306E-9	
+0.5 V	t1	85.78173	3.41102	
-0.5 V	y0	-3.64402E-8	2.00241E-8	
-0.5 V	A1	5.44633E-8	1.00121E-8	
-0.5 V	t1	86.93599	5.31245	
-1.0 V	y0	-7.82322E-8	5.61837E-8	
-1.0 V	A1	1.22587E-7	3.01955E-8	
-1.0 V	t1	91.99107	7.88102	

DISCUSSION

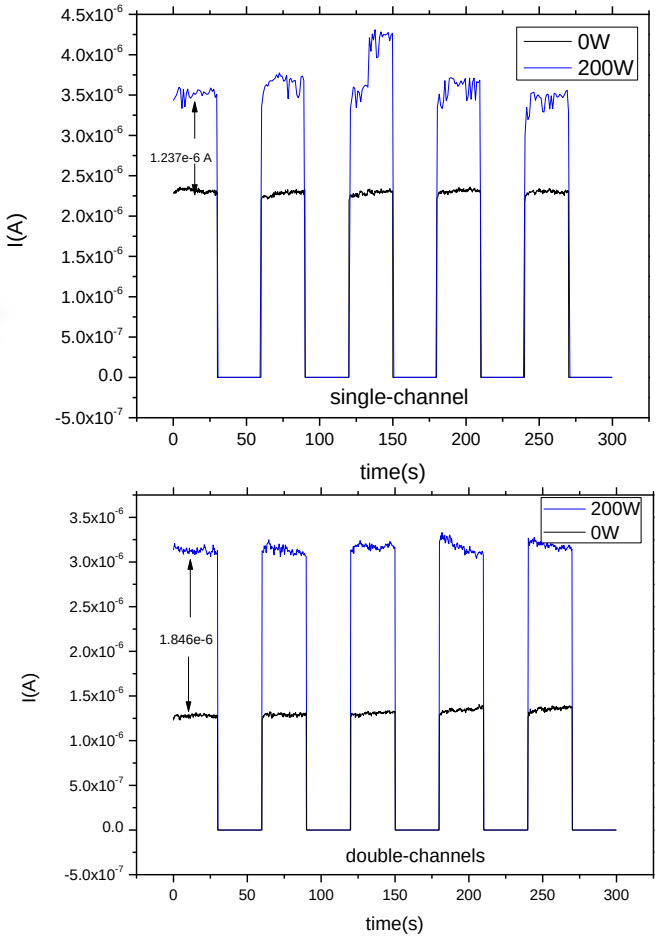
	Measured current at 200W (µA) Vds = 2.0V	Increasing of Measured current from 0W to 200W (µA) Vds = 2.0V	Transconduc-tance at 0W (µS) Vds = 2.0V	Transconduc-tance at 200W (µS) Vds = 2.0V
Single channel	4.11	1.84	1.06	1.17
Parallel channels	3.13	1.83	0.781	0.922

DISCUSSION





- Scattering
- Unconventional Schottky barrier
- loss energy by heat dissipation



CONCLUSION

- The excited charge carriers in the SWCNTs by increasing light emission power up to 200 W was found linearly dependence of the power
- In a comparison with a parallel conductive FET channels, the measured single conductive FET channel exhibits a higher trans-conductance
- The measured current of both devices shows small increases with light powers when applying gate biases and saturates at a high power
- We demonstrated that the carbon nanotube materials can be used for light sensor application or energy harvesting materials for low-power consumption technology

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ACKNOWLEDGE

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THANK YOU FOR YOUR ATTENTION

Q&A