Electromagnetic field propagation in graphene in the range 40 MHz-110 GHz

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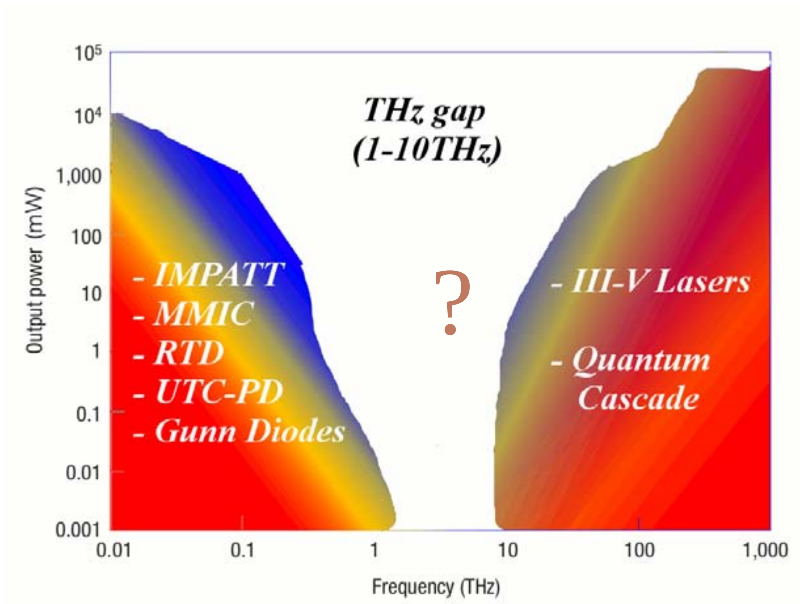
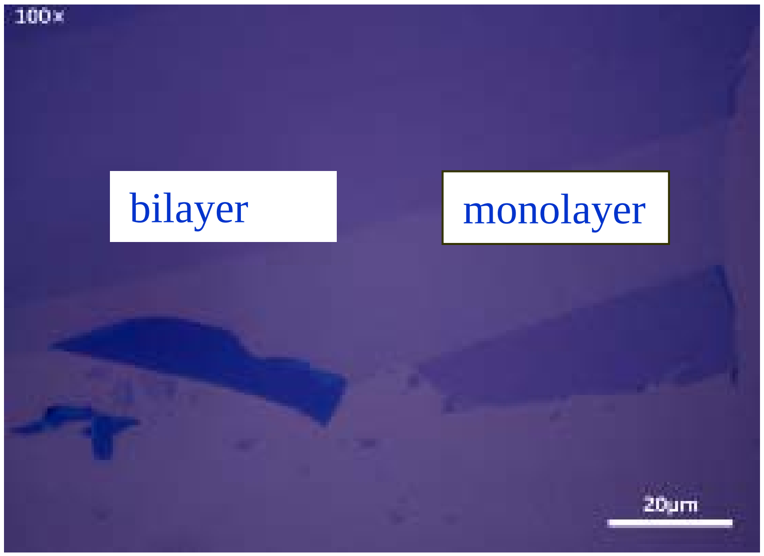
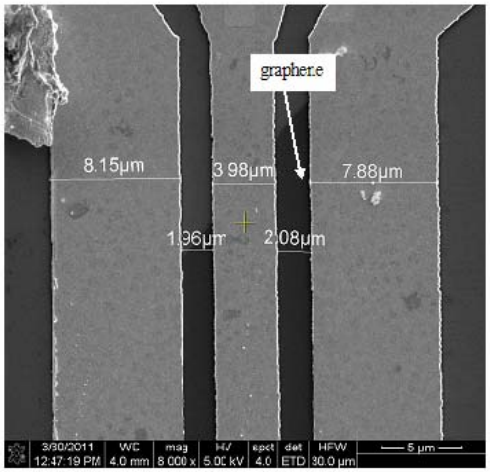
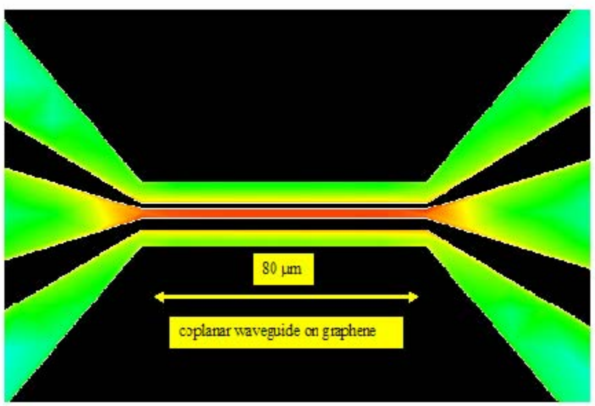
In analogy to the famous Moore law, the Edholm law states that *"the need for higher bandwidth in wireless communications doubles every 18 months"*. In modern wireless LANs the carrier frequency is 5 GHz and the corresponding data rate does not exceed 110-200 Mb/s. However, following the ever increasing demand for wireless communication, the data rate is expected to reach 5Gb/s in 8-10 years. In order to accommodate such an increase, the carrier frequency for wireless communications should reach and possibly exceed 100 GHz, thus approaching the terahertz domain. In that frequency range, there is a severe lack of enabling devices

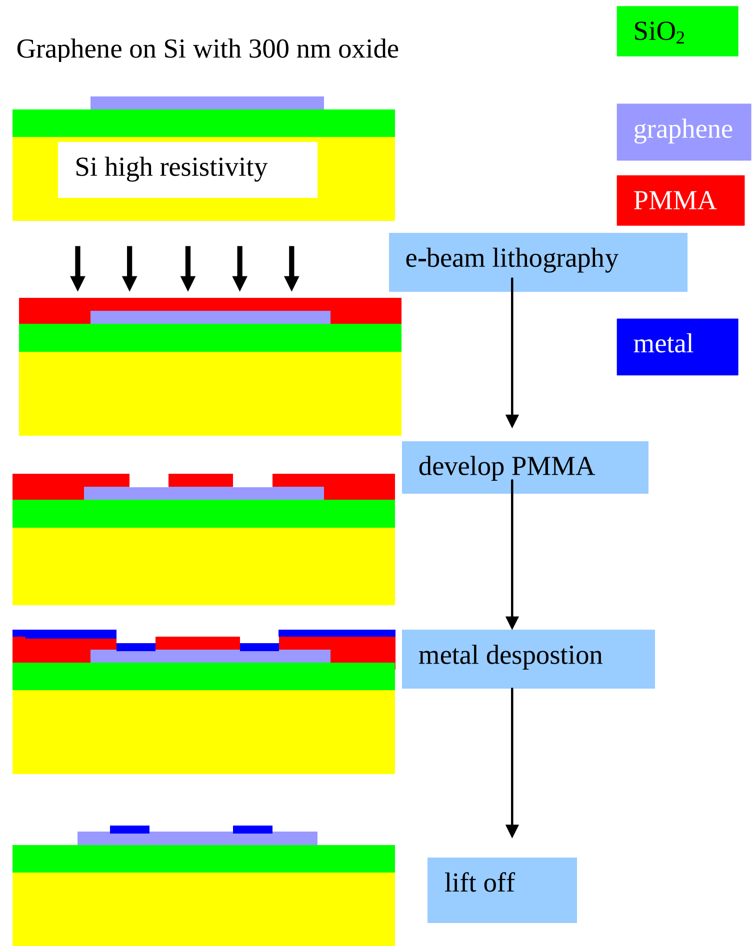


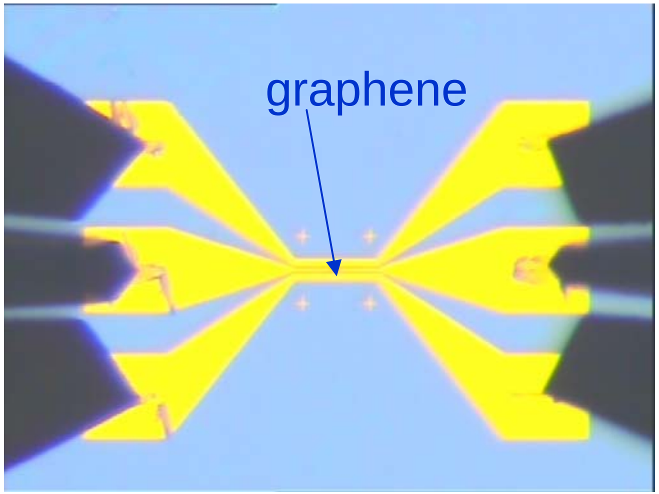


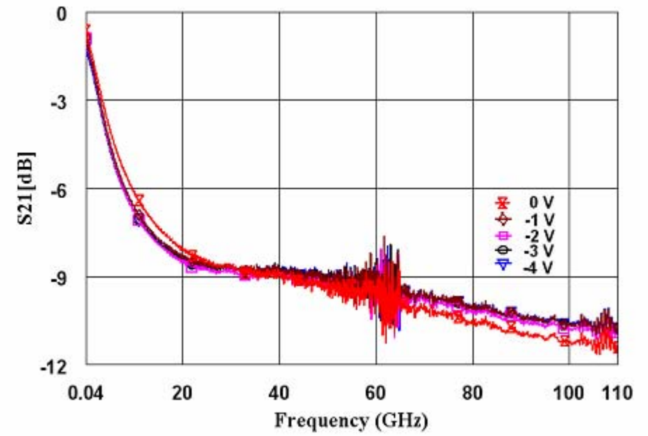
Parameter	*Value and units*	*Observations*
Thermal conductivity	5000 W/mK	Better thermal conductivity than in most crystals
Young modulus	1.5 TPa	Ten times greater than in steel
Mobility	40 000 $cm^2V^{-1}s^{-1}$	At room temperature (intrinsic mobility) maximum mobility : 200 000 $cm^2V^{-1}s^{-1}$) on suspended graphene or graphene on hexagonal BN substrate
Mean free path (ballistic transport)	≈400 nm	At room temperature, but exceeds 1 μm in graphene on hexagonal BN substrate at room temeperature
Electron effective mass	0	At room temperature
Hole effective mass	0	At room temperature
Fermi velocity	c/300=1000000 m/s	At room temperature


graphene
8.15µm
3.98µm
7.88µm
1.96µm
2.08µm

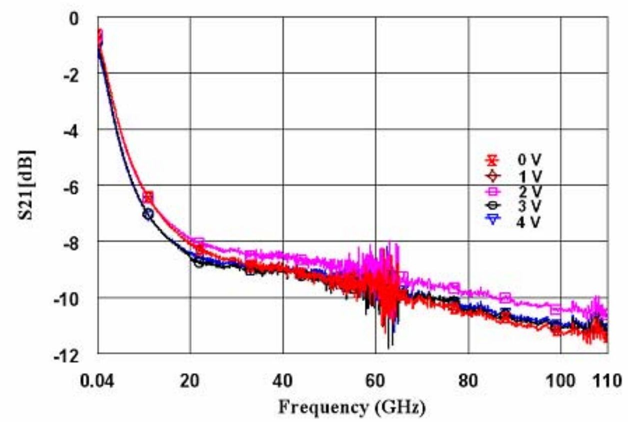

80 µm
coplanar waveguide on graphene


Graphene on Si with 300 nm oxide
SiO2
graphene
PMMA
metal
Si high resistivity
e-beam lithography
develop PMMA
metal despostion
lift off

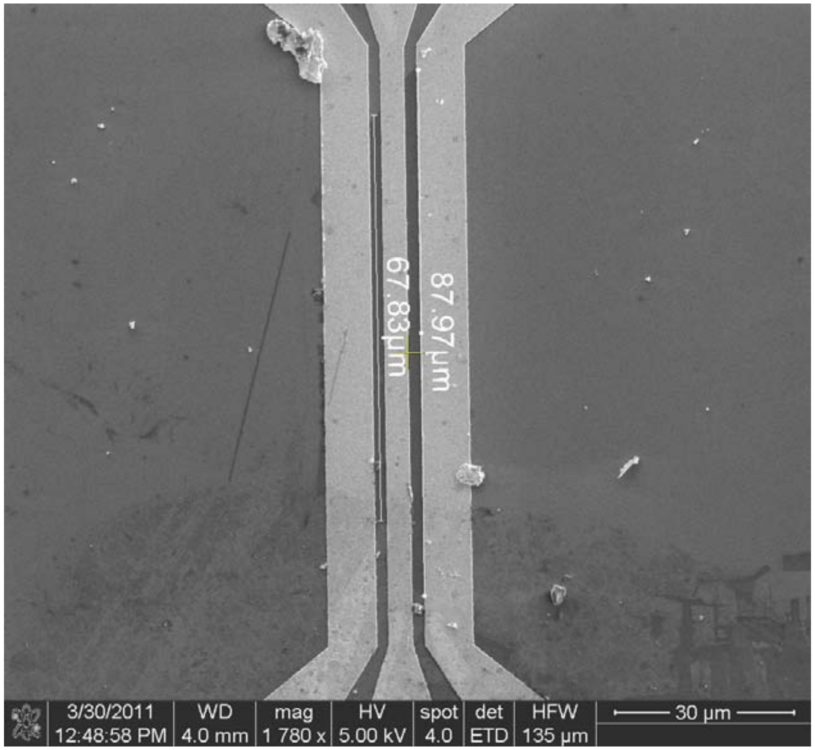

graphene

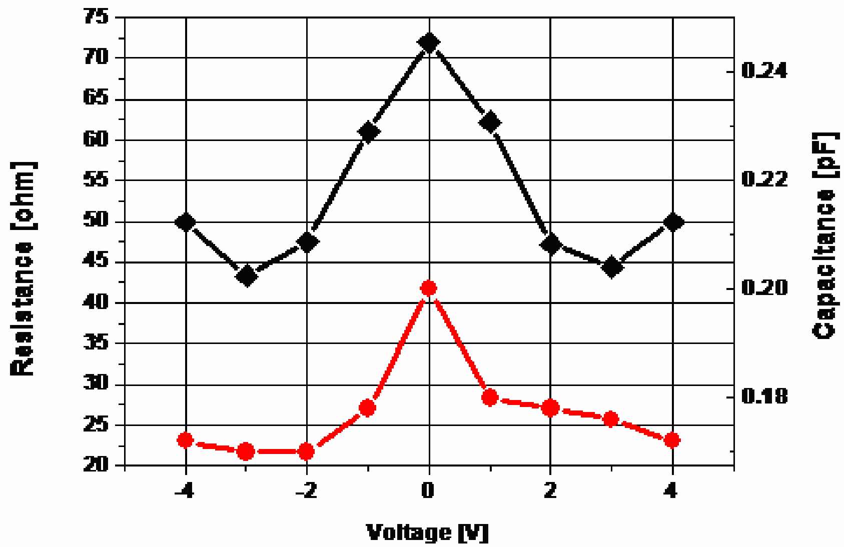

S21[dB]
Frequency (GHz)
0 V
-1 V
-2 V
-3 V
-4 V

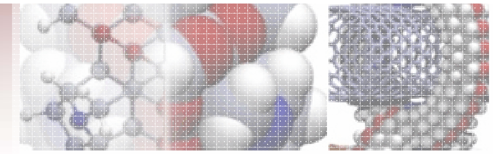
(a)


S21[dB]
Frequency (GHz)
0 V
1 V
2 V
3 V
4 V

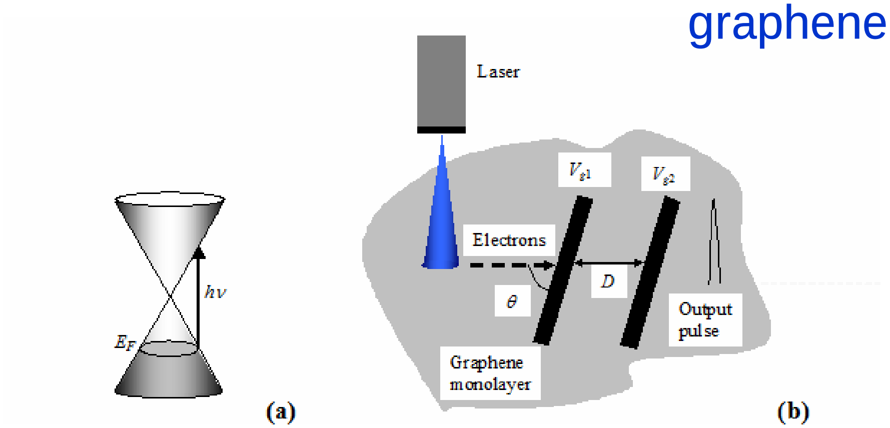
(b)


67.83µm
87.97µm
3/30/2011
12:48:58 PM
WD
4.0 mm
mag
1 780 x
HV
5.00 kV
spot
4.0
det
ETD
HFW
135 µm
30 µm


Resistance [ohm]
Capacitance [pF]
Voltage [V]
75
70
65
60
55
50
45
40
35
30
25
20
0.24
0.22
0.20
0.18
-4
-2
0
2
4



Conclusions –What's next?



The photocurrent is maximum if, as in (a) the Fermi energy level in graphene, measured with respect to the Dirac point, is E_F=hν/2 . Then, vertical transitions generate an electron pulse with an energy distribution centered around E_F , which is directed by an applied bias towards two oblique gates with different widths, and , and polarized with different biases, and ; an output pulse is finally collected

THz generation using an RTD-like graphene device

The electrons produced by a short laser pulse incident on a graphene monolayer excite two oblique gates polarized with different dc voltages. The two gates are biased such that the quantum transmission has an isolated sharp peak in a narrow energy bandwidth. Such a transmission mimics the main property of a resonant tunneling structure, usually consisting of a semiconductor heterostructure, and generates an electric pulse with sub-picosecond duration and a spectrum with a cutoff frequency that can exceed 10 THz.

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