Density of states and zero landau level probed through capacitance of graphene


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Graphene density fluctuations

M. Wilson, Physics Today, 21, 2006

08.04.2011 J. Martin, doi:10.1038/nphys781, 2007
Landau levels in graphene

- Resistivity:
  \[ \rho_{xx} = R_{xx} \frac{W}{L} \]
- Density:
  \[ n = \frac{B}{e \cdot \rho_{xx}} \]
- Mobility:
  \[ \mu = \frac{\sigma_{xx}}{n \cdot e} \]

Measuring the quantum capacitance

- Total capacitance:
  \[ \frac{1}{C} = \frac{1}{C_{ox}} + \frac{1}{C_{q}} \]
- \( C_{ox} \) independent of \( V_g \)
- \( C_{q} = e^2 D = e^2 \frac{dn}{dE} \)
Sample fabrication

- Exfoliation of graphene
- High resistive Si-wafer
- Ti/Au contacts
- 1nm Al deposition (1Å/s)
- Oxidation with O₂ at 0.1mbar
- 100nm Al deposition
- \( \mu = 10000 \text{cm}^2/\text{Vs} \)
Capacitance at B=0

\[ \frac{1}{C} = \frac{1}{C_{ox}} + \frac{1}{C_q} \]

\[ C_q = e^2 D = e^2 \frac{dn}{dE} \]

\[ D \propto \frac{1}{v_F} \]

Magnetocapacitance oscillations measurements:
B-field const., sweeping Vg.
\[ \Delta n = \frac{4eB}{\hbar} \rightarrow C = \frac{e\Delta n}{\Delta V_g} \]
Integrated capacitance data

![Graph showing capacitance data vs. Fermi energy](image)
Capacitance at $B=16T$

**Graph a**

- $C_Q (\mu F/cm^2)$ vs. $V_g (V)$
- $B = 16T$: 20 K, 60 K, 100 K, 150 K, 250 K
- $B = 0$: 20 K

**Graph b**

- $C_Q (\mu F/cm^2)$ vs. $n (10^{12} cm^{-2})$
Zero LL measurements

\[ D_i(T) = \frac{\Delta n}{\pi} \int_0^\infty e^{-\Gamma_0 t} \cos(E_i t) \frac{\pi T t}{\sinh(\pi T t)} dt \]
Conclusion

• Measurements of graphene’s capacitance give another approach for investigations of quantization phenomena in graphene

• Quantum capacitance of graphene has been measured and compared with theoretical values

• $0\text{LL}$ was shown to be robust against scatterers and temperature

• Broadening of the LL with respect to B and T were measured
Density of states in graphene

- Resistivity:
  \[ \rho_{xx} = R_{xx} \frac{W}{L} \]

- Density:
  \[ n = \frac{B}{e \cdot \rho_{xx}} \]

- Mobility:
  \[ \mu = \frac{\sigma_{xx}}{n \cdot e} \]

- Quantum Capacitance:
  \[ C_q = e^2 D = e^2 \frac{dn}{dE} \]