Interactions Between Two Independently Contacted and Rotationally Aligned Graphene Layers

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I. Motivation
- Graphene double layers may enable novel low-power, low-voltage logic devices.
- Graphene 2D-2D tunneling field-effect transistors: rotational alignment key for momentum conserving tunneling, and negative differential resistance.

II. Devices Without Rotational Alignment
- Independent Hall-bar geometry on top and bottom flakes
  - Channel width of 6µm
  - Device length of 19 µm
  - Total overlap area of 35 µm²
  - Overlap areas are device dependent
- Both the bottom and the top flake have high mobilities with low impurity carrier concentrations
- Resistance profiles reflect Dirac point and probe combinations

III. Calculating Specific Interlayer Resistance
- Calculated using extracted parameters from top and bottom flakes
- Several devices ranging from 2.5 – 7.8 x 10⁻⁵ Ω·cm²
- Several orders of magnitude higher than out of plane graphite

IV. Exfoliated Graphene Pathway to Rotational Alignment
- Exfoliated graphene monolayers are single crystal
  - Every monolayer has a single crystallographic orientation
  - Isolate a very large exfoliated graphene
    - Split the crystal in two sections!
    - Keep track of orientation!
    - Stack the two sections!

V. Addition of dielectric
- SiO₂, plasma - to define active area
- SiO₂ exfoliated silicon contacts
- 5 nm thick dielectric layer deposition

VI. Guaranteed Rotational Alignment
- Fully overlapped, rotational alignment to less than 1 degree
- Several devices made
  - Various dielectric possibilities, including ultrathin HBN
  - Process being improved to avoid polymer residues

VII. Summary
- Theory predicts rotational alignment will be key in achieving negative differential resistance
- Non-rotationally aligned devices fabricated as a baseline
- Model created to extract the specific interlayer contact resistance of the graphene to graphene interface
- The graphene to graphene contact resistance is 2.5 - 10⁻⁴Ω·cm²
- Single large grain graphene has been split and overlapped with a rotational alignment of less than one degree
- Several large grain overlap devices made, reproducible results
- Current issues in device cleanliness, specifically residues from the transfer process.

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