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NANO LETTERS

Letter

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Visualizing Electrical Breakdown and ON/OFF States in Electrically Switchable Suspended Graphene Break Junctions

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Supporting Information

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BUTE

Sample

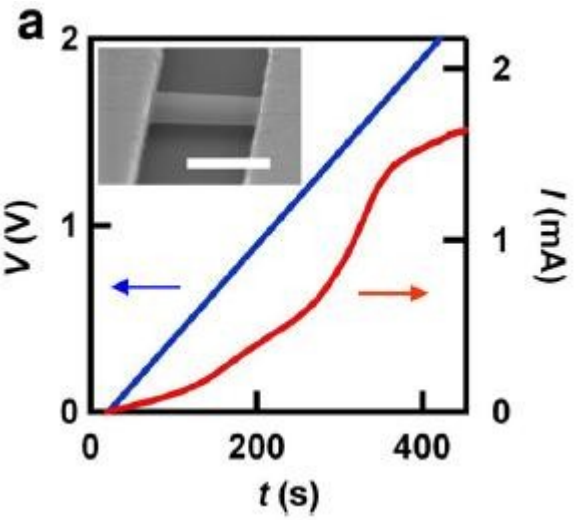
Si/SiO_2 (300 nm) substrate

1-5 layer graphene (mechanical exfoliation)

2 methods:

- EBL and 120 nm oxide etching
- Exfoliaton on prepatterned substrate (250 nm deep)
  - 10/70 nm Ti/Au with shadow mask

G_{2p} ~ 0.5 mS



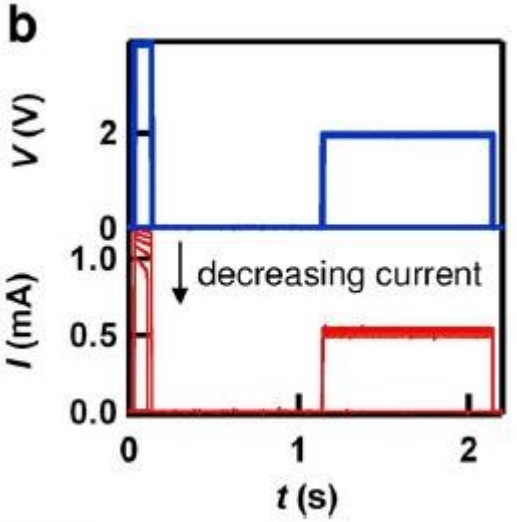
Electromigration (in situ SEM vid):

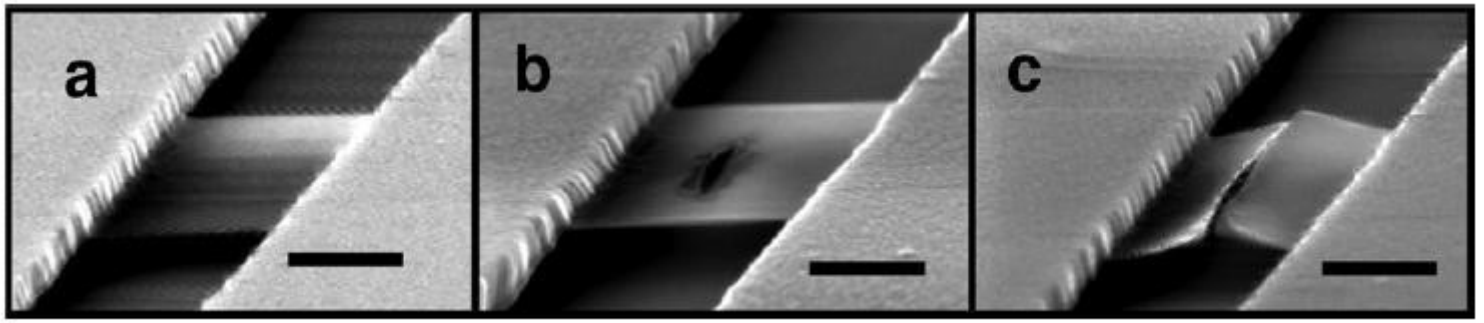
High vacuum: 10^{-6} Torr

~ 4 V pulse → ~2mA/μm

~ 2 V test voltage

Start: center/edge (depend on T, defects etc.)



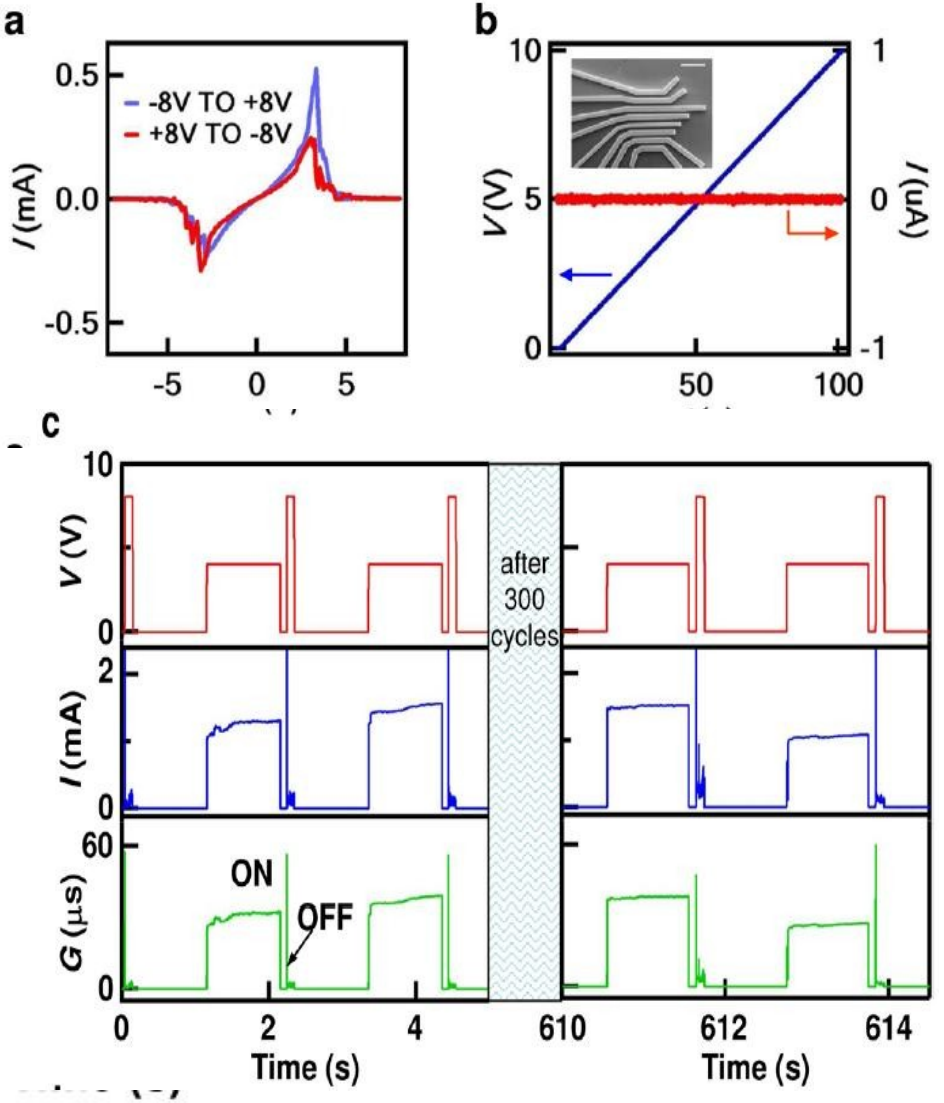


Switch

UHV needed (clean sample)
- Atomic motion
- Chemical rearrangement
- Both

Open @±4V ('ON') 25-40μS
Close (8V pulse) ('OFF') ~1μS
Hunderds of cycles
- Less cycle before failure than @ nonsuspended samples

Control device: w/o graphene
- Almost zero current @10V
- Breakdown @210 V



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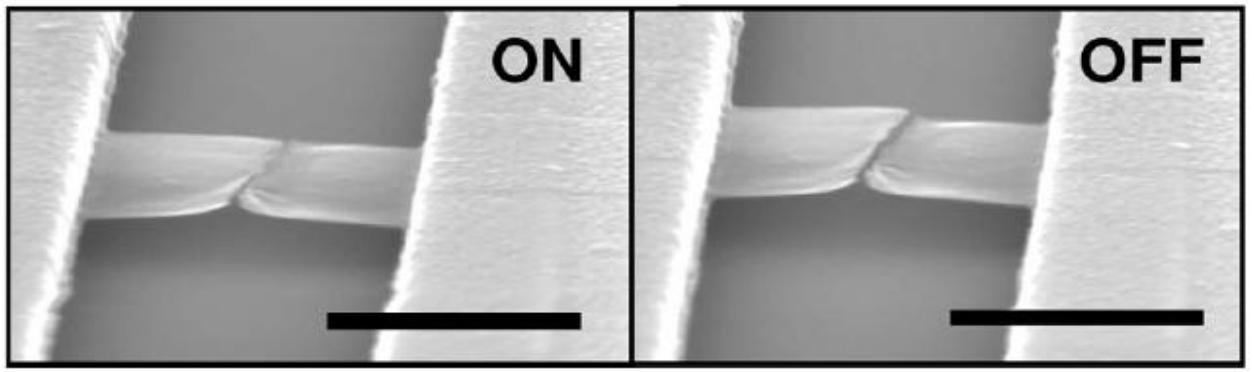
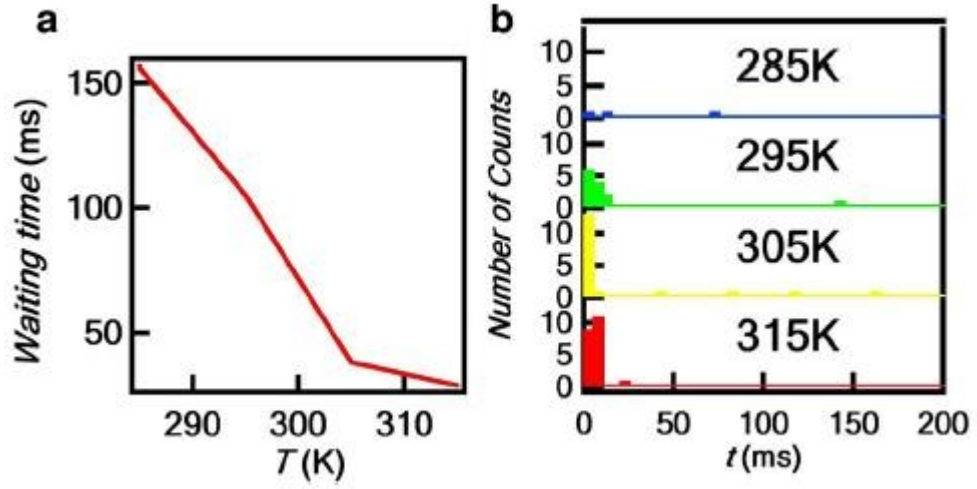
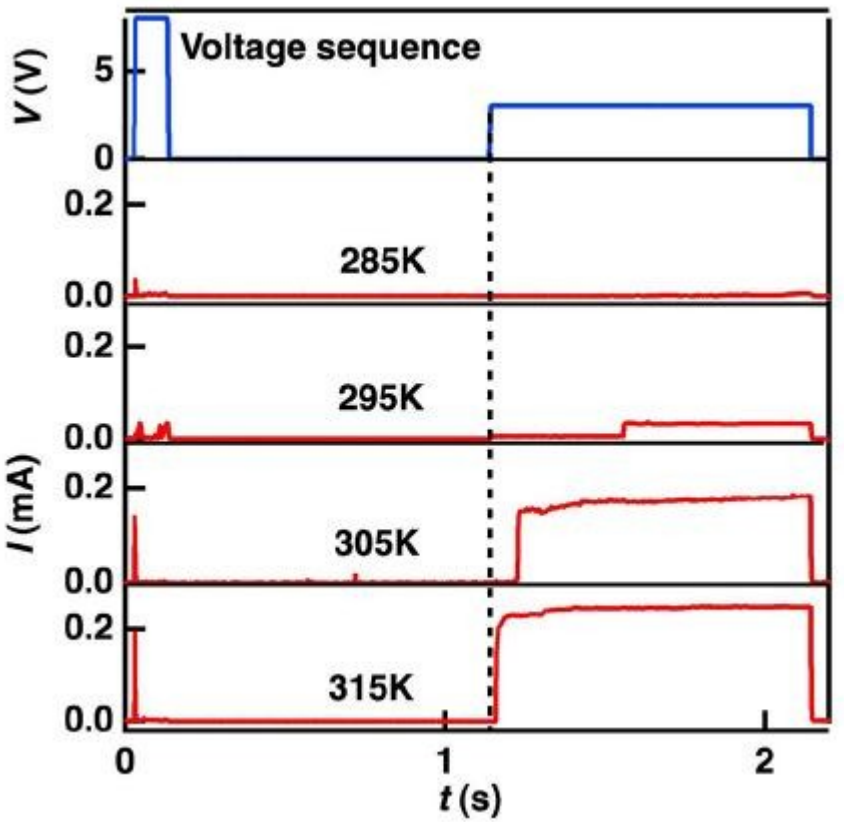


Temperature dependence





No switching @4.5K
Very rare under 280 K
Estimated max freq: ~ 1 MHz
(graphene cantilever)
Another time scale ~ 1 ms
Measured timescale: ~100ms – 1s >> 1 ms
Elastic properties: weak T dependence
Switching not limited by nanomechanical motion, but atomic motion/ chemical rearrangements (~eV energy scale)