Observation of Terahertz Stimulated Emission of Radiation from Optically Pumped Graphene

Silvia H. Chan1,2, Stephane Boubanga-Tombet2, Amine El Moutaouakil2, Akira Satou2, and Taiichi Otsuji2

1NanoJapan Program, Rice University and Department of Materials Science & Engineering, University of Pennsylvania
2Research Institute of Electrical Communication, Tohoku University, Sendai, Japan

WHAT’S GRAPHENE?

• Mono- or few layers of sp2 bonded carbon atoms in a honeycomb lattice.
• Massless Dirac Fermions obey linear dispersion relation at K & K’ points.
• High carrier mobility of 2 x 10⁵ cm²/Vs at RT.

Due to its unique transport properties, graphene is suitable for implementation in photonic devices.

OBJECTIVE

To stimulate terahertz (THz) emission by implementing electro-optic sampling (EOS) time-resolved spectroscopy to optically pump and THz probe exfoliated graphene ribbons (GR) on SiO₂ sample.

THEORY

Non-equilibrium Carrier Dynamics in Optically Pumped Graphene

Electrons and holes relax and accumulate near the Dirac point. Due to graphene’s negative dynamic conductivity in THz range, population inversion can be achieved for stimulated emission of THz lasing.

SETUP & METHOD

1. Setup Laser Pathway for Pumping and Probing

- Pump & Probe Pulses: 1.5μm, 80fs, 2mW
- Bandwidth: ~7THz

2. Excite Graphene with Femtosecond Pulse Laser

- Coherent THz emission: ħω
- Optical Pumping: ħΩ
- THz Probe
- Cascade emission of optical phonons: ħνₚ

3. Isolate Graphene Response Peak & FFT to Obtain THz Emission Information

- THz probe delay from the optical pumping
- Optical probe
- Photocrystal
- Optical pump
- EOS signal (arb. unit)
- Time (ps)

RESULTS

1. Verification of THz Emission from Graphene

- Figure 1: Graphene THz Response

2. THz Emission Dependence on CdTe Crystal Thickness

- Figure 2: THz emission intensity vs. CdTe thickness

3. THz Emission from Monolayer vs. Bilayer GR

- Figure 3: Comparison of THz emission for monolayer and bilayer graphene

CONCLUSIONS

• THz coherent emission was successfully observed in optically pumped graphene.
• Thinner CdTe gives rise to an emission spectra shifted to lower frequencies compared to those of the thicker CdTe. This discrepancy might be attributed to the usage of a different crystal orientation.
• The emission spectra of monolayer GR was found to be broader than those of bilayer GR. The parabolic band structure of bilayer GR accelerate relaxation dynamics and gives rise to narrow spectra at lower frequencies.

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REFERENCES

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