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Direct Synthesis of Graphene on Niobium Superconductors

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Background & Motivation

Why direct growth of graphene on niobium?

Graphene is a single atom thick hexagonal lattice of carbon. Its isolation and initial characterization in 2004 [1] generated massive interest from the scientific community because of its unique physical and electronic properties. Of interest to this work:

- Ballistic electron transport. In graphene, electrons have a mean free path in the lattice that is longer than the conductor dimensions, i.e. electrons travel without scattering and with little to no energy dissipation. [2]
- Proximity induced superconductivity. Placed in contact with a superconductor, i.e. electrons move without resistance, and do not need an external voltage source to maintain a current. [3]

Creating highly electron transparent graphene-superconductor interfaces remains difficult, so ballistic conduction in this system is still not well characterized. Direct graphene growth on a superconductor vs. transfer promises a higher quality interface, see Figure 1 (a & b). [4]

Objective

The synthesis few-layer graphene on niobium and niobium nitride nanofilms supported on industry standard silicon dioxide wafers

Methods

- CVD of niobium on SiO₂
  - 200 nm niobium and niobium nitride films were deposited on silicon dioxide wafers via chemical vapor deposition (CVD).

Direct growth of graphene by PECVD

- Wafers were subjected to various growth regimes in a plasma enhanced chemical vapor deposition (PECVD) system.

Characterization by Raman Spectroscopy

- Wafers were characterized by Raman spectroscopy to see the effectiveness of the chosen growth regime.

Results

Growth trials were performed in a PECVD system designed and built by current research group members, see Figure 2.

Discussion

What do these results mean?

- We have demonstrated that both niobium and niobium nitride can self-catalyze the dehydrogenation of acetylene gas both with and without a plasma. This is shown directly by the presence of D, G, and 2D peaks in the Raman spectra, Figure 3.
- The progression of the 2D to G peak ratio as we moved from a plasma regime Figure 3 (a & b), to a non plasma regime Figure 3 (c), shows we are moving to more graphene like films in our results. Figure 4 is a reference for the peak ratios we are aiming for.

Conclusions / Future Work

- Based on the progression of our results so far, direct growth of graphene on niobium and niobium nitride appears possible.
- Next steps are to transfer currently grown films to a bare SiO₂ wafer and obtain Raman spectra from this known substrate. This will rule out the possibility of interference of the graphene signal by the niobium substrate.

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