CVD Graphene Growth on Copper and Refractory Metal Substrates

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Primary CNF Tools Used: CVD Equipment/First Nano graphene furnace for growth, Zeiss SEM and optical microscopes for characterization, wet benches for substrate cleaning

Abstract:

We used CNF's graphene furnaces to attempt direct CVD graphene growth on refractory metal and copper/refractory metal alloy substrates. Varying sizes and substrates thicknesses were deposited, with the goal of depositing graphene on refractory metal directly (copper was included for benchmarking).

After deposition, we used the CNF scanning electron microscope to inspect our substrates. Other equipment (cutting tables, lab desks, vacuum packing) was used to clean and prepare samples for deposition, and to package and seal our samples after deposition in the CNF clean room.

At a later date, we plan to return to do work on encapsulation techniques.

Summary of Research:

As an early manufacturer in the production and sale for graphene to world markets through sales channels such as Digikey, our products have focused on graphene on copper substrates, and manually transferred graphene onto substrates other than copper (silicon, PET, poly, etc.).

As our customers move from experimentation in research environments to commercial industry, handling, quality and cost constraints have created a need to eliminate the manual transfer of graphenewhere possible. Semiconductor applications using baseplates for high power RF and power gallium nitride (GaN) semiconductor devices in satellite communication and cellular base stations are one such example.

In this case, the coefficient of thermal expansion (CTE) of GaN (6) is mismatched to copper (18) traditionally used to mount and cool die, and baseplates of refractory metals (tungsten or molybdenum) or their alloys with matching CTE’s are substituted to prevent failures due to CTE mismatch (premature cracking between die and flanges). However, while thermal stress problems are resolved, thermal conductivity plummets and die have to be powered down, or derated to shorter life spans. Graphene addresses this issue when combined with refractory metal, as thermal effectiveness of the baseplates climbs back up when graphene is added to metal stacks.

By growing graphene on tungsten and molybdenum baseplates directly, we will be able to avoid copper growth and manual transfer steps to refractory metal, as coated substrates will ultimately remain in end customer product systems. Direct growth eliminates costly and time consuming manual transfer steps of the graphene on copper process, and in situ deposition improves quality and eliminates PMMA residue which can contaminate the graphene and decrease performance.
Figure 1: Metals being loaded into SEM after growth for analysis.

Figure 2: Mixed material (molybdenum, tungsten, Mo and W copper alloys, titanium, etc.) baseplates being loaded into the First Nano graphene furnace.

Figure 3: Interesting SEM image resembling T-Rex dinosaur found during SEM work.