Encapsulation of Photocathodes in Two-Dimensional Materials

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Primary CNF Tools Used: CVC SC4500 odd-hour evaporator, Glen 1000 resist strip

Abstract:

We are developing a new technique for encapsulating highly reactive photocathodes in an atomically thin membrane that protects them from oxidation and degradation without affecting their photoemission properties or chemical purity.

Summary of Research:

Photocathodes are materials that eject electrons under illumination. By their very nature, high-performance photocathodes must be made from materials that lose electrons easily — in other words, materials that are easily oxidized. For example, many photocathodes are either coated with alkali metals (e.g., Cs/GaAs) or comprised of alkali metals (e.g., Cs_3Sb). This presents a technical challenge, as exposure to even trace amounts of O_2 or H_2O will destroy or degrade the photocathode. For highest performance, the photocathodes must also be atomically flat and extremely homogeneous.

To meet these challenges, we are developing a technique to produce photocathodes encapsulated in two-dimensional materials, such as graphene or hexagonal boron nitride. The key challenge in this project is ensuring that every step of the fabrication leaves no residue on the surface, as even monolayer levels of contamination could significantly reduce photoelectron transmission and beam brightness.

In the first step of fabrication, commercial two-dimensional materials, which are grown on a copper foil, are coated with a thin gold layer in the CVC SC4500 thermal/e-beam evaporator. The two-dimensional material on the backside of the copper foil is then removed using 100W of oxygen plasma in the YES oxygen plasma asher. The copper foil is then removed with an aqueous etchant, allowing the graphene side of the gold-coated graphene to be adhered to a low energy substrate. The gold film is then removed by a second aqueous etch.

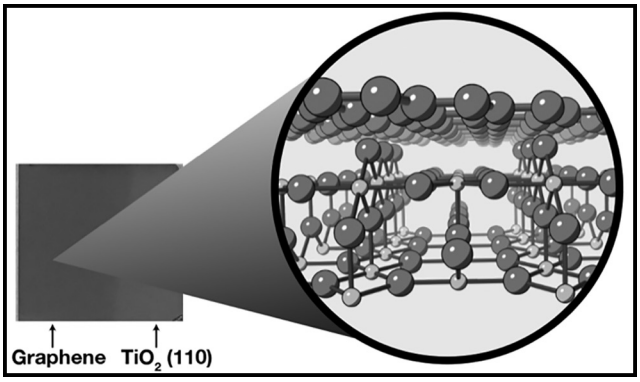

Figure 1: Optical image of TiO_2(110) with single-layer graphene on left side. The inset is a model of single-layer graphene on TiO_2(110).