**Application of large-area hexagonal Boron Nitride for SERS**

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**Introduction**

hexagonal Boron Nitride (hBN) is a 2D allotrope of BN which has a honeycomb like structure similar to that of graphene. It is a wide bandgap semiconductor with good chemical and thermal stability. Recently, ultrathin layers of hBN were used for passivating gold nanoparticles for surface enhanced Raman spectroscopy (SERS). We report on application of large-area hBN, grown using metal organic vapor phase epitaxy (MOVPE) for passivating silver nanoparticles (Ag NPs) and validate its use for SERS. Ag NPs are known to yield highest sensitivity for SERS, but are prone to rapid oxidation in ambient conditions, and hence are not preferred over gold NPs. Here, we show that oxidation of Ag NPs can be prevented by hBN coatings and its SERS activity can be retained even after annealing at 400 oC in air.

Figure 1 (a) hBN coated SERS substrate with 2-l droplets of R6G, (b) SEM of SERS substrate, (c) and (d) SERS spectra before and after thermal annealing respectively

**Methods**

Epitaxial growth of hBN was undertaken on commercially available 2” sapphire substrates in a closed coupled showerhead type MOVPE reactor [1]. Triethylboron (TEB) and ammonia as boron and nitrogen sources respectively, and hydrogen as the carrier gas. Growth temperature was 1300 oC. The properties and characteristics of hBN layers were studied using different techniques like Raman spectroscopy, atomic force microscopy and transmission electron microscopy. Centimeter-sized, (few layer thick) hBN was also transferred onto Ag NPs substrates using a wet transfer technique [2].

**Results and Discussion**

We studied the stability of hBN passivated Ag NPs against oxidation by annealing the SERS substrates, shown in figures 1 (a) and (b), at 400 oC in air for 2 hours. To test SERS functionality, Rhodamine 6G (R6G) was used as a model molecule. SERS substrates were dipped in a 1 mM solution of R6G for 1 hour, before and after annealing. Samples were rinsed with DI water post R6G soak. For comparison, Raman spectra were obtained from hBN and non-hBN coated regions on the same sample, before and after annealing. Figure 1(c) compares, the Raman spectra of R6G collected from hBN and non-hBN coated regions before annealing. We can see that Raman peak intensity for hBN coated Ag NPs is higher than bare Ag NPs because of hBN’s superior adsorption power. However, in case of annealed samples, a sharp decrease in Raman signal from bare Ag NPs is recorded, compared to hBN protected region as shown in figure 1(d). This apparent loss in SERS activity for bare Ag NPs can be attributed to their oxidation, which is prevented by wrapping NPs with hBN film and therefore SERS functionality is preserved.

**References**

1. Chugh, D., et al., Flow modulation epitaxy of hexagonal boron nitride. 2D Materials, 2018. 5(4): p. 045018.
2. Chugh, D., C. Jagadish, and H. Tan, *Large-Area Hexagonal Boron Nitride for Surface Enhanced Raman Spectroscopy.* Advanced Materials Technologies. **0**(0): p. 1900220.