The Electrochemical and Optical Properties of Diamond Optically Transparent Electrodes

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The presentation will discuss the fabrication, characterization and application of optically transparent diamond electrodes (OTE's). Electrically conducting diamond has a number of important attributes as an electrode material, particularly for electroanalysis. One material property that has not yet been exploited in electrochemistry or chemical analysis is diamond's optical transparency. High quality diamond has one of the widest optical windows spanning from the UV into the far IR. Three types of OTE's will be discussed: (i) free standing boron-doped diamond disks (8 mm diam. and ~350 μm thick), (ii) boron-doped diamond thin films (~1-2 μm thick) coated on "white" (optically pure) diamond substrates (8 mm diam.) and (iii) boron-doped diamond thin films (~1-2 μm thick) coated on undoped Si substrates (1 cm diam.). The main emphasis of our research at this time is on the material development, specifically learning how to manipulate and control the optical properties in the UV, visible and IR regions of the electromagnetic spectrum through adjustments in the deposition conditions. The diamond OTE's currently being developed have 40-60 % transmissivity from 225 to 900 nm and from 1100 to 500 cm^{-1}. The utility of the OTE's in transmission spectroelectrochemical measurements will be demonstrated for both aqueous (e.g., ferri/ferrocyanide and methyl viologen) and nonaqueous (e.g., ferrocene) redox systems.

Three major benefits of diamond, as compared to commonly used indium-doped tin oxide OTE's, are (i) stability in acidic media, (ii) the ability to be used during cathodic polarization spectroelectrochemical measurements and (iii) a reasonably well-defined and stable surface chemistry. Additional advantages include (i) a wide working potential window in excess of 3 V in aqueous media, which allows one to study redox reactions over an expanded potential range and (ii) a low and stable background current, which leads to improved S/B ratios.

The research is leading to a new class of OTE's for use in spectroelectrochemical measurements. Our long-term goals are to use these dimensionally stable and responsive materials in spectroelectrochemical measurements, both in the transmission and attenuated total reflectance modes. Specifically, we plan to develop these materials for chemical analysis in harsh environments and structure-function studies of redox proteins and enzymes.