Pyrolytic Graphite Electrode Information

Product Testing and Materials Disclaimer

Important information about Pine Research Instrumentation pyrolytic graphite electrodes. Please review this information prior to use. Contact Pine with any questions.

1. Material Source Disclaimer

Pyrolytic graphite (PG) is a highly oriented form of graphite material manufactured through chemical vapor deposition. Chemical vapor deposition is a process by which molecules are grown atom-by-atom; for PG, sp^2 hybridized carbon atoms form covalent bonds with other sp^2 hybridized carbon atoms to make a flat, hexagonal structure called a graphene sheet. Multiple layers of graphene sheets are constructed during the process, and the layers are held together through weak interactions between unhybridized p_z –orbitals of adjoining carbon atoms. The PG electrodes from Pine Research Instrumentation are manufactured from large pieces of PG and cleaved either along the basal or edge plane (see Figure 1).

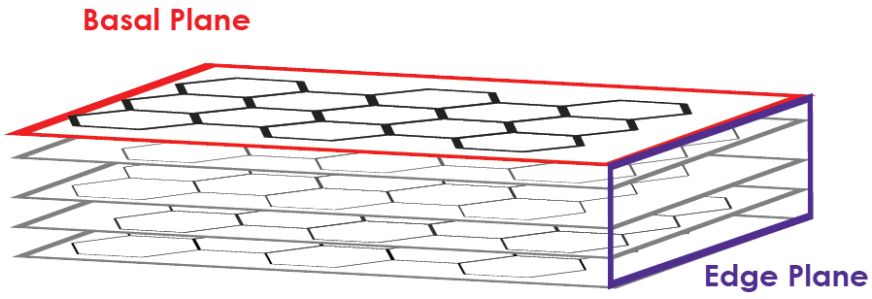

Figure 1. Pyrolytic Graphite Basal and Edge Planes

When PG material is manufactured into electrodes, the possibility always exists that the composition may not be entirely uniform over the entire electrode surface. Imperfections in the chemical vapor deposition process lead to some covalent bonding between graphene sheets, though the number of imperfections is very small. Larger differences in surface composition arise as a consequence of graphite's strong anisotropy in the areas of bonding, structure, and electronics. For example, edge plane PG materials undergo heterogeneous electron transfer faster than basal plane PG materials due to a larger local density of states available for electron transfer. In addition, impurities at edge planes, especially oxygen-containing functional groups that spontaneously form under aerobic conditions, have a high impact on the local density of states available for electron transfer. As a result, the voltammetric behavior of a PG electrode is known to change depending upon the treatment received by the electrode surface prior to use (some treatments are known to preserve basal planes and other treatments introduce edge planes and varying levels of surface impurities).

In general, PG electrodes from Pine Research Instrumentation are shipped with a sub-micron finish achieved by using sub-micron alumina powder. Given that there exists a wide body of literature and lore describing various procedures, rituals, and recipes for "activating" the surface of a PG electrode, some researchers may opt to further prepare the surface of a PG electrode prior to use.

Pine Research Instrumentation recognizes that in some electrochemical applications, a researcher may require more control over the material used to manufacture a PG electrode. In these situations, Pine Research Instrumentation is usually able to fabricate custom electrodes from material supplied by the researcher. Contact Pine Research Instrumentation for further details.

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Info:

In light of the discussion above, Pine Research Instrumentation makes no warranty, express or implied, regarding the surface characteristics, surface chemistry, or surface morphology of pyrolytic graphite electrodes.

2. Product Use Warning

Pyrolytic graphite is a brittle material that requires additional stabilization to maintain the disk-like shape of an electrode. For this reason, Pine Research Instrumentation encapsulates all of its PG electrodes in epoxy. Prolonged exposure of epoxy to non-aqueous solvents causes it to swell and break. Therefore, PG electrodes should only be used in aqueous solutions.

Chemical Compatibility:

Pyrolytic graphite electrodes are for aqueous use only. Using pyrolytic graphite electrodes in non-aqueous systems will cause the epoxy encapsulation to swell and break.

Researchers are warned that PG electrodes should not be used at highly oxidative potentials for long periods of time (for example, $+2\,V$ in $1.0\,M\,H_2SO_4$ for days) as this may permanently and irreversibly damage the pyrolytic graphite. Electrodes damaged in the manner described here cannot typically be repaired nor their surface regenerated through traditional polishing methods.

Caution:

Do not use pyrolytic graphite electrodes at highly oxidative potentials for long periods of time, as this will irreversibly damage them.

3. Pyrolytic Graphite Electrode Manufacturing Evaluation

Pine Research Instrumentation routinely evaluates every permanent (fixed disk) pyrolytic graphite electrode as part of the manufacturing process. Only those that pass our electrochemical and visual inspections are sold to customers. The cyclic voltammogram obtained using the electrode is examined, and features such as the current magnitude, peak current and position, zero current crossover, and capacitive hysteresis are evaluated. This evaluation assures that there is no solution leakage around the shroud/epoxy/electrode interface. Visual inspection assures that any surface defects observed are within typical limits for commercially available PG.

3.1 Electrochemical Testing

Pine Research Instrumentation typically evaluates PG electrodes in an aerobic sulfuric acid solution at room temperature; a cyclic voltammogram that is free of redox peaks (other than oxygen) is desired (see Figure 2). A copy of this test is provided with the purchase of all permanent (fixed disk) pyrolytic graphite electrodes.

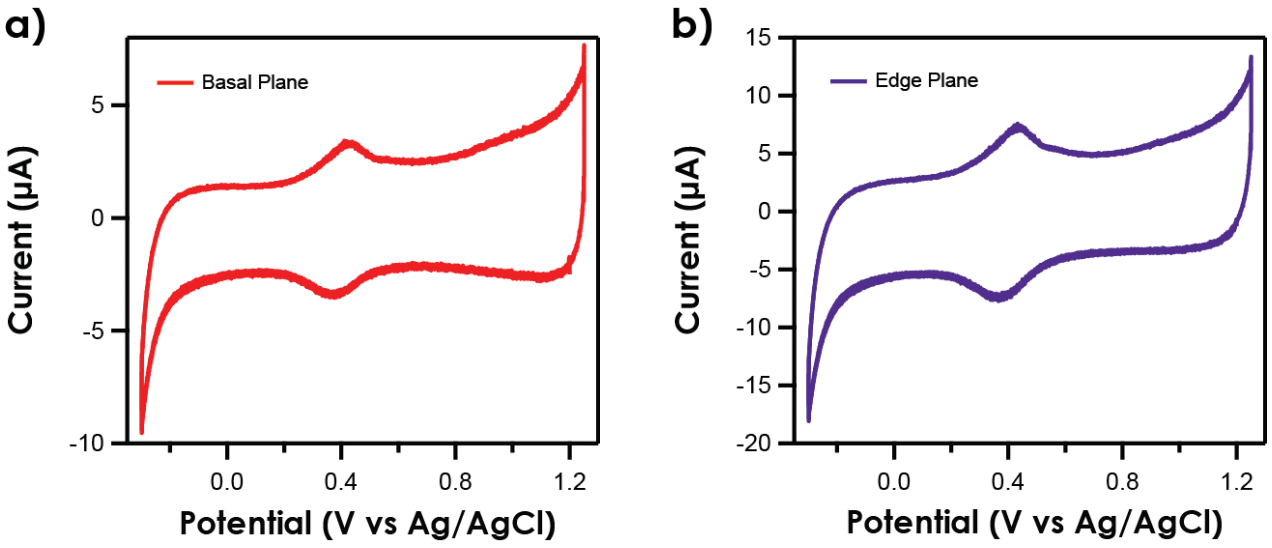

Figure 2. Pyrolytic Graphite Cyclic Voltammogram Test with a) Basal Plane and b) Edge Plane Electrodes

3.2 Visual Inspection

All PG surfaces must exhibit fewer than *x* defects when viewed under 25x magnification (see Figure 3).

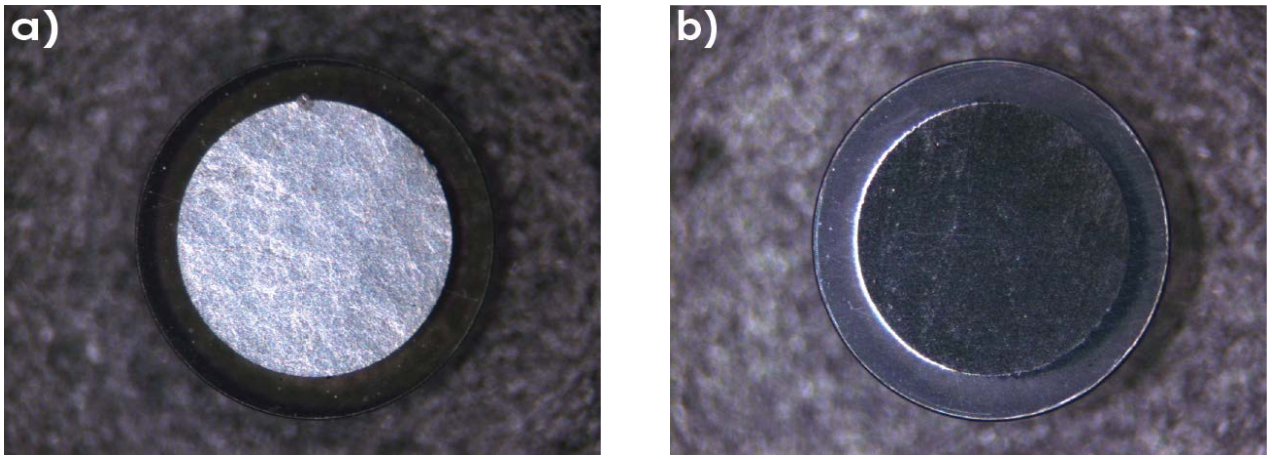

Figure 3. Surface Magnification of a) Basal Plane and b) Edge Plane Electrodes

4. Support

If you have any questions about the pyrolytic graphite electrodes described in this document, please contact us via the means provided below:

4.1 Email

Reach us by emailing the entire sales department: pinewire@pineinst.com.

4.2 Website

There is a contact us form on our website. There may also be additional resources for the products mentioned here: http://www.pineresearch.com

