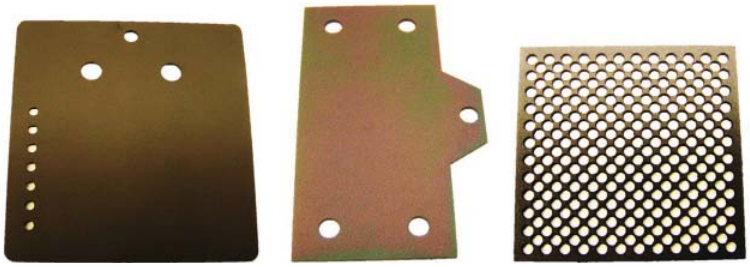
ADVANCED DIAMOND TECHNOLOGIES, INC.

UNCD® Electrodes—Diamond for Water Treatment

Bringing the Power of Diamond to Electrochemical Water Treatment Technologies

UNCD Electrodes bring all the superior properties of diamond to water-treatment companies who are developing and supplying electrochemical water treatment technologies for industrial and municipal applications. Whether it's in-line advanced oxidation processing or on-site generation of oxidants such as hypochlorite, ozone, or persulfate, UNCD Electrodes can significantly lower the capital costs needed to construct the system while also lowering the operating costs and the total cost of system ownership due to higher system reliability and up-time. Advanced Diamond Technologies' (ADT) UNCD technology allows diamond to be run in operating conditions far beyond what is achievable with conventional diamond technology, producing oxidants with high production rates and energy efficiency with greater reliability compared to other electrode materials. UNCD Electrodes enable the lowest water treatment cost for many applications.



Above: Boron-doped UNCD films on niobium and tantalum substrates. UNCD Electrodes are customizable and are suitable for a wide range of electrochemical applications.

Applications

- On-Site Generation of Oxidents
- Electrochemical Advanced Oxidation Process
- Any Electrochemical Application, such as electrosynthesis

UNCD Electrodes Technical Specifications

Substrate Type: Nb (99.9% or better) substrates are standard.
Ta (99.9% or better) available upon request.
Substrate Thickness: 1 or 2 mm +/- 0.3 mm
Substrate Minimum Size: 1 cm x 1 cm
Substrate Maximum Size: 18 cm X 15 cm (larger sizes available)
Minimum Hole Size in Substrate: 1 mm diameter
UNCD: boron-doped nanocrystalline diamond
UNCD Thickness: 2 µm +/- 0.5 µm
UNCD Deposition Conditions: ~750 °C deposition temperature
UNCD Film Resistivity: <0.1 ohm-cm

UNCD Electrodes Benefits

- Reduce costs associated with water treatment
- Reduce complexity, decrease maintenance costs, and increases the mean time between failure of electrode systems
- Improves safety by eliminating the need to transport and handle hazardous chemicals
- Supports environmentally sustainable water treatment technologies that reduce energy consumption and the carbon footprint of industrial plants
- Brief periods of reverse polarity completely descale electrodes

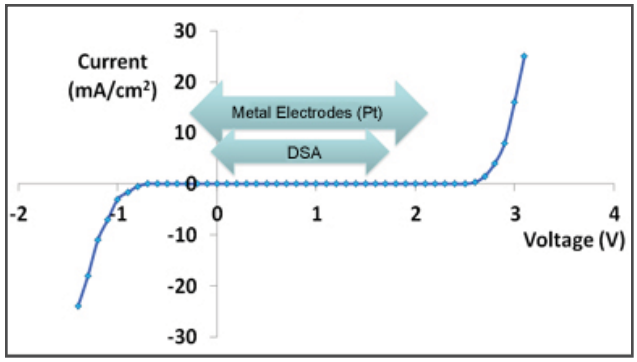
UNCD® Electrodes—Diamond for Water Treatment

UNCD, a form of nanocrystalline diamond, captures many of the best properties of natural diamond in a scalable thin film technology that enables diamond to be integrated into a wide range of products. UNCD is the term that encompasses a proprietary family of materials that are manufactured using patented chemical vapor deposition processes. UNCD can also have unique properties not found in any other carbon-based material that can be adjusted and optimized for a given application.

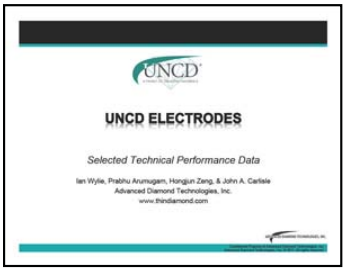
Electrochemical Properties of UNCD Electrodes

- **High over-potentials for oxygen and hydrogen evolution.** This means electrical energy is used to drive desired chemical reactions with high current efficiency, and not waste energy to make gas.
- **Long operational lifetimes compared to other diamond technologies.** In accelerated lifetime testing UNCD Electrodes can withstand being run at 2-3 A/cm^2 current densities for weeks at a time. Lifetimes in excess of five years at more moderate current densities are expected even for continuous operation at less than 600 mA/cm^2.
- **Reverse polarity capability.** UNCD Electrodes can be operated under reverse (cathodic) polarity conditions without damaging the surface or reducing electrode lifetime. Descaling occurs in a matter of seconds.
- **High efficiency generation of hydroxyl radicals on electrode surface.** Hydroxyls are the most powerful oxidant known and are the precursor to a number of chemical reactions useful for many purposes including direct oxidation of waste chemicals, oxidant production, and electro synthesis of other chemical compounds.
- **High resistance to electrode fouling.** Due to diamond's low surface energy, residue does not easily adhere to the diamond surface and can be cleaned by briefly reversing polarity on the electrode.
- **No conditioning needed.** No burn-in needed before the electrodes are used; the surface chemistry of diamond is extremely stable and remains stable even after thousands of hours of operation.
- **Dimensional and chemical stability.** UNCD Electrodes don't get consumed by string acidic or basic electrolytes or the oxidants they generate. UNCD Electrodes can also be operated at extremely high current densities yet retain their electrochemical characteristics compared to conventional electrodes.
- **Biocompatible and bioinert.** Diamond is intrinsically a highly biocompatible material, and the UNCD material has been certified as being United States Pharmacopeia Class VI compliant.

Cyclic Voltammogram of UNCD Electrode in 1M $NaClO_4$



UNCD Electrodes are ideal for direct oxidation of organic and inorganic waste and for on-site generation of advanced oxidation including hypochlorite, ozone, peroxodisulfate, peroxycarbonate and mixed oxidants.



To see more techincal data, visit www.thindiamond.com/electrodes

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