



1 Hot-filament CVD installation for the large-area coating (up to 50 cm x 100 cm) of electrodes with conductive diamond

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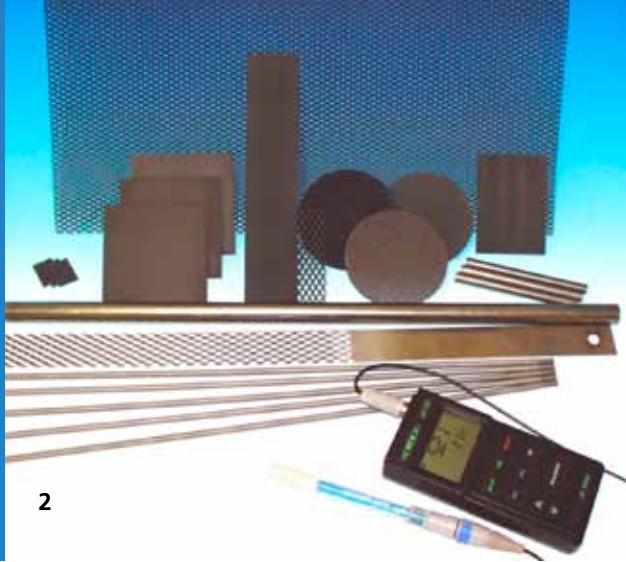
DIAMOND ELECTRODES

Diamond is found in nature as a crystal of different sizes and degrees of perfection. Diamond crystals can also be produced synthetically by so-called high-temperature high-pressure synthesis in which the diamond is created in a manner similar to the natural crystal. The crystals are used in industry mostly for machining or cutting, either directly or in the form of sintered platelets.

Continuous diamond films can be deposited directly upon base bodies by activated gas-phase deposition, thereby improving, for example, the wear resistance of even complex-shaped tools and components. At the Fraunhofer IST, the addition of boron to the activated gas phase results in the diamond films deposited on the predominantly metal or silicon base bodies being conductive and therefore usable

as electrochemical electrodes. Alongside their outstanding physical properties, these diamond electrodes have in particular chemical and electrochemical properties which make them very suitable as industrial electrode material for the electrochemical treatment of water and for electrochemical synthesis.

The Diamond Technology department of the Fraunhofer Institute for Surface Engineering and Thin Films IST is developing installations (Fig. 1) and processes for boron-doped, conductive polycrystalline diamond electrodes on different base bodies (Fig. 2). The hot-filament CVD used for activating the gas phase does so by means of hot filaments at temperatures up to 2800 °C and permits the manufacture of diamond electrodes measuring up to 100 cm x 50 cm (Fig. 2).



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Advantages

Diamond electrodes are characterized by an unusual combination of chemical and electrochemical properties:

- Extreme chemical stability (no corrosion in aggressive media, such as, for example, HF)
- High electrochemical stability (for example, 750 h at 10 A/cm² in 1 M sulfuric acid)
- Extremely high overvoltage for the electrolysis of water (cathodic -1.2 V vs SHE and anodic +2.6 V vs SHE; see graph)
- High current yields for the generation of oxidants, including OH[•] radical, directly from the water

These properties can be used in the treatment of contaminated water. The electrochemical treatment of water with diamond electrodes is characterized by:

- Effectiveness in the treatment of water polluted with persistent, not readily degradable substances
- Water purification with low energy input and without additional chemicals
- Uncomplicated electrical control, no dosing with chemicals

The technology we offer

In the treatment of wastewater or process water the special properties of diamond electrodes are used for water disinfection and for the complete oxidation of persistent pollutants. In the field of electrosynthesis, developments are concentrating not only on the synthesis of chemical products such as persulfate but also on organic synthesis.

The Fraunhofer IST's work in the field of diamond electrodes includes besides the development of the coating technology the carrying out feasibility studies with laboratory cells (Fig. 3), working out electrochemical process parameters, developing adapted electrochemical cells and integrating the technology module into an overall concept for an integrated water treatment system.

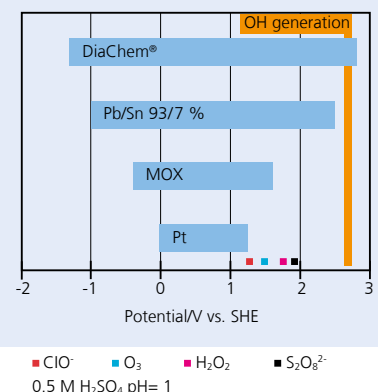
The Fraunhofer IST as a partner

The marketing of the diamond electrodes has been given to a spin-off company, Condias GmbH, located in Itzehoe, north-west of Hamburg. This company not only markets diamond electrodes but also, in collaboration with partners, develops system solutions with diamond electrodes for the most varied industrial applications

in the fields of water treatment and electrochemical synthesis. Such system solutions may even consist of a combination of conventional methods and process steps based on diamond electrodes. The Fraunhofer IST is active as a development partner of Condias GmbH.

In the Fraunhofer Water Systems Alliance (SysWasser) the electrochemical water treatment technology forms one module in the technology portfolio. Several Fraunhofer institutes are involved in the SysWasser Alliance. Here the institutes pool their various areas of competence in the field of water with a view to researching, developing and implementing sustainable system solutions for the water supply, for water infrastructures and for wastewater

Overvoltages for water with different electrode materials. DiaChem® is the trade name under which Condias GmbH markets diamond electrodes.



- 2 Geometries and material modifications of diamond-coated electrodes.
- 3 Test set-up with a microchannel diamond cell for performing feasibility studies.