Investigation of DiaChem® Electrodes for Industrial Applications

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Coating conventional electrode materials with doped conductive diamond films yields innovative DiaChem® electrodes with unique properties for industrial electrochemical processes. Despite high doping levels DiaChem® electrodes keep the extreme chemical stability of diamond. What is even more important, these electrodes show a high overpotential for water decomposition which opens new opportunities for improved and also new electrochemical processes.

For the investigation of conductive CVD diamond for industrial electrochemical DiaChem® electrodes with different geometries and dimensions have been fabricated using hot-filament CVD with in-situ boron doping[1]. Diamond deposition with growth rates between 0.1µm/h and 1.5µm/h was performed mainly on metal plates, rods and expanded metals with typical dimensions of up to 50cm in length and up to 20cm wide. Electrical resistivities needed for the investigations are in the range of (5-100)mΩcm corresponding to doping levels of a few thousand ppm of boron.

DiaChem® electrodes have been loaded with increasing current densities up to several A/cm^2 in sulfuric acid over months. No degradation of the electrode surface nor the electrochemical performance could be detected, thus demonstrating the extreme chemical stability of these new electrodes.

The investigation of chemical oxygen demand COD reduction and current efficiencies has been performed applying electrochemical cells with DiaChem® electrodes (Figure 1). The new DiaChem®-based electrochemical advanced oxidation processes (EAOP) for the treatment of industrial waste water show effective COD reduction as well as high current efficiencies. Thus EAOP is advantageous for integration in waste water treatment schemes.

Additionally, DiaChem® electrodes exhibit increased efficiencies in electrochemical synthesis, e.g. the production of peroxodisulfuric acid (Figure 2). The successful application of DiaChem® electrodes in electroplating processes has also been demonstrated e.g. by the oxidation of Cr^{III} to Cr^{VI} in chromic-sulfuric acid processes for etching of plastics. Compared to conventional lead and Ti-based Pt anodes the required electrode area and energy could be reduced considerably.

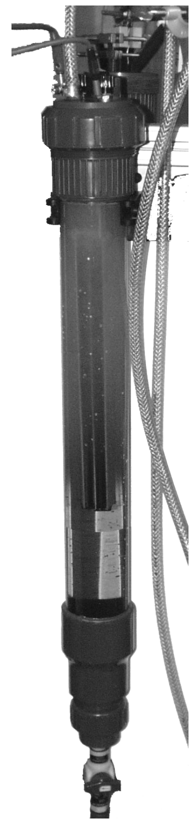

Figure 1: Electrochemical cell with DiaChem® electrodes (4,5cm x 30cm) for EAOP of industrial waste water. Cell design and fabrication by G.E.R.U.S. mbH, Berlin

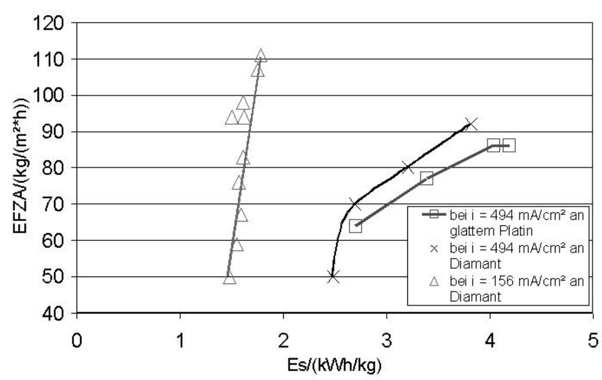

Figure 2: Production of ammonium peroxodisulfate with different electrode materials. Highest production efficiency obtained with diamond electrodes at low current densities (triangles). Comparable, but lower productivities for diamond (crosses) and conventional platinum electrodes (rectangles) at typical current densities. Measurements performed by Infracor, Germany.

References

1 M. Fryda, D. Herrmann, L. Schäfer, C.-P. Klages, A. Perret, W. Haenni, C. Comninellis, D. Gandini, New Diamond and Frontier Carbon Technology, 9 (1999) 229