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Noble metal coated high-aspect-ratio nanopore arrays and porous nanotube networks for catalysis in chemical synthesis and fuel cells

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Nanopore arrays, fabricated by the track-etching technique, mostly in Polycarbonate (PC) or Polyethylenterephthalate (PET) foils, are commercially available. These are formed by irradiation with highly energetic ions, such as Ar, from e.g. a cyclotron, and chemically etching the damage tracks up into cylindrical nanopores. For the present study, a linear heavy ion accelerator was applied, and, next to PC and PET, also Polyimide with a better chemical and thermal stability than the polyesters was used. The foils were up to 30 µm thick, the nanopores with an areal density up to 10-9 cm-2 had a diameter of down to 10 nm, corresponding to very high aspect ratio tubes.
Uniformly coating the inner walls of those nanopores with a thin reactive metal film constitutes a challenging process, since the thin film material transport into the nanopores has to be well controlled, particularly to avoid clogging of the apertures. By means of a kinetically controlled electroless deposition process, the nanopore inner walls were uniformly coated with thin films of gold, platinum, palladium, platinum-ruthenium, platinum-palladium, and palladium-coated nickel, leading to respective nanotubes embedded in the polymer foil. This has been evidenced by cross-sectional SEM and TEM investigations.
Embedded Pd nanotubes were tested for their performance as catalyst for a flow-through reactor. In UV-Vis absorption spectrometric measurements, they showed a very high efficiency towards the nitrophenol reduction to aminophenol, used for the fabrication of paracetamol (acetaminophen), the well-known analgetic and antipyretic [1]. The nanotubes show an advantage over comparable nano particle based systems: in contrast to the latter, they are more mechanically stable and do not agglomerate, leading to a better long-term stability of the catalyst.
When the ion beams tracks in the polymer foil are crossed and the resulting nanopores are coated with metal, the dissolution of the polymer foil leads to free standing porous nanotube networks. Due to the cross-linking, they are mechanically very stable, despite the very small diameter of the individual nanotubes. With their large internal surface area, they constitute highly efficient catalysts for the methanol oxidation in Direct Methanol Fuel Cells. This has been shown for Pt-Pd alloy and Pd-doped Ni networks by means of electrochemical half-cell methanol oxidation measurements [2, 3].

Participation

In-Person

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