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Ion Damage Tracks in Polymers - Fabrication of 1-Dimensional Nanostructures: Nanochannels, Nanowires and Nanotubes

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Abstract

Radiation damage tracks of heavy ions in polymer foils and their chemical etching into nanochannels in combination with (electro)chemical treatment offers a versatile technique for fabrication of 1-dimensionsal nanostructures: functionalized nanochannels, nanowires and nanotubes.

When ions of heavy elements with large kinetic energy and a high charge state cross a polymer foil, they set energetic electrons free (delta-electrons) that are able to break covalent chemical bonds. Along the ion trajectories, the polymers show both a reduced density and a lower chemical stability. Here, the polymers can chemically be etched with a large track-to-bulk etch ratio, thus forming high-aspect-ratio nanochannels (ion track etching method). An example is the formation of a 10 nm diameter nanochannel in a 10 micrometer thick polyester foil by irradiation with 2 GeV Au-ions. Polymer films with such nanochannels can act on one hand as a filter or a sensing device and on the other hand they can be used as a exotemplate for fabricating 1-dimensional nanostructures such as nanowires and nanotubes. For this purpose, the nanochannels are homogeneously filled with metals or oxides, either galvanically or redox-chemically. The electrochemical deposition yields solid nanowires, the electroless deposition nanotubes that are obtained by depositing a thin film onto the nanochannel walls. When the template is removed by chemical dissolution, the nanostructures are set free.

In the present contribution, the ion damage track formation in the polymer is described and the template technique and its parameters for etching nanochannels are explained.

From the wide range of applications of the obtained 1-D nanostructures several will be shown: Examples of the application of nanochannels as (bio)chemical sensors after chemically modification by attaching biorecognition molecules will be presented. Typical application fields are medical diagnostics and environmental sensing.

In case of the metallic nanowires and nanotubes, applications in (electro)catalysis in microreactors, as fuel cell electrodes and for force/acceleration sensing will be presented.