NARODOWE CENTRUM NAUKI

MINIATURA 5

Plasma-enhanced chemical vapor deposition of thin-film carbon-nitrogen semiconductive catalysts

Carbon-nitrogen materials are well-known for their semiconductive properties. Among these materials, there are e.g. graphitic carbon nitride [1–3] or polyaniline [4]. Currently, the carbon-nitrogen materials are successfully studied in terms of photocatalytic hydrogen production [5,6]. The most common methods for the synthesis of these materials are polymerization and polycondensation processes. The original idea in this context is plasma-enhanced chemical vapor deposition (PECVD), which allows obtaining the thin-films (below 1 μm) of a variety of materials. This novel and still developed method is based on a decomposition of organic or metal-organic compounds in the glow discharge, under low pressure, with subsequent coupling reactions leading to the deposition of thin-film material [7,8]. In the literature, there are examples of the PECVD application to the synthesis of the carbon-nitrogen materials from the mixture of N_2, CH_4, and H_2 [9], the mixture of N_2 and CH_4 [10], or the mixture of NH_3 and C_2H_2 [11]. There are also, several reports dealing with the synthesis of the carbon-nitrogen materials from compounds containing both elements. [12,13]. This latter approach seems to be the most interesting because allows designing the structure of the deposited materials on a molecular level. This approach allows the doping of the materials during plasma deposition. Doping of the carbon-nitrogen materials with, for example, cobalt, enhances the photocatalytic activity [14,15].

The aim of this project is the synthesis of the thin-film carbon-nitrogen materials via the PECVD method. The project covers the systematic studies on the influence of operational parameters (pressure, precursor feeding rate, applied power, or the type of the precursors applied) on the molecular structure, nanostructure, and photocatalytic activity of the obtained materials. The precursors to be studied are mainly volatile organic compounds (eg. methylamine, acetonitrile, acrylonitrile, aniline), as well as volatile metal-organic compounds (containing e.g. cobalt, iron, or nickel), which will introduce the atoms of metals playing the role of the electronic dopant. It should be emphasized that materials synthesized in this approach will be a new class of carbon-nitrogen semiconductors. Thin films will be deposited onto silicon and ITO (indium-tin-oxide). The predicted result of this project is the obtainment of the thin-film catalysts active in various photocatalytic processes.

The materials obtained will be studied to determine their phase composition via X-rays diffraction methods (XRD). Moreover, chemical composition will be analyzed via X-ray photoelectron spectroscopy (XPS), X-ray microanalysis (EDS), and infrared spectroscopy (FTIR). Morphology and nanostructure will be studied with scanning electron microscopy (SEM). Then, selected materials will be studied in terms of their photocatalytic activity in hydrogen production via (i) photocatalytic water splitting, and (ii) methanol reforming.

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