There has been growing interest in the **environmental friendly alternative energy sources** and methods of **formation of fuels and utility chemicals**. In this respect, the low-temperature electrochemical approaches comprising modern fuel cell technology (including hydrogen-oxygen systems), electrolytic methods (**conventional and visible-light-induced photoelectrochemical systems**) seem to be very promising.

Having in mind tremendous recent drive toward possible **applications of fuel cells** (mostly hydrogen-oxygen but also methanol-based) in automotive industry, there has been continuous interest in development of electrocatalytic systems ***for the efficient oxygen reduction reaction***. Here special attention has been paid to development of both noble-metal-free and low-platinum-content electrocatalytic materials for the **oxygen reduction** with the ultimate goal of **lowering formation of undesirable H_2O_2 intermediate**.

Regarding the continuously rising levels of atmospheric carbon dioxide, the development of advanced technologies permitting the **CO_2 utilization** is highly desirable. In this respect, there has been growing recent interest in the effective **conversion of carbon dioxide**, a potent greenhouse gas and a contributor to the global climate change, to simple but useful carbon-based fuels or chemicals. The **CO_2-reduction products** are of potential importance to energy technology, food research, medical applications and fabrication of plastic materials. In principle, **conventional electrocatalytic and photoelectrochemical approaches** are well-suited for the effective reduction of carbon dioxide and possible generation of carbon-based fuels or chemicals. To achieve this goal, highly specific and selective catalysts would be required to drive effectively conversion (reduction) of carbon dioxide (and water) into fuels, synthesis gas or useful chemicals. Because even, at the most efficient catalytic systems, the electroreduction of CO_2 still requires large over-potentials and suffers from hydrogen evolution. Therefore, there has been growing interest in photoelectrochemical approaches **utilizing p-type semiconductors** as the main component of the CO_2-reduction photocathodes. An ultimate goal is to use **visible (solar) light** to generate electrons at potentials (close to the conduction band edge) sufficiently negative to drive the electroreduction process. But common p-type semiconductors (e.g. Cu_2O) require **stabilization, activation and modification** to increase interfacial electron densities and preparation of the respective systems is proposed in the present proposal.

Formation of **ammonia** is one of the most important chemical synthetic processes. Under industrial conditions, ammonia is primarily been synthesized from nitrogen and hydrogen via the Haber-Bosch process which requires pressurizing, heating, and utilization of catalysts. Consequently, **development of the low-temperature synthetic methodology** is tempting both from the practical and fundamental reasons. Additional goal of the proposed research is to **generate NH_3 from N_2 under electrochemical conditions at temperatures lower than 100°C, atmospheric pressures** and with use of new generation of catalysts. Among important issues are development of **highly selective** and functionalized catalysts, as well as **optimization of the catalyst composition and structure,** in addition to the **experimental conditions**. All these parameters will be optimized towards efficient N_2-electroreduction. Any progress in the area is of primary importance not only to the electrochemical science and technology but catalysis, in general.

The results obtained during realization of the project should lead in near future to the development of various (**both noble-metal-free and with low-Pt-content) selective catalysts toward oxygen reduction** in which the formation of the undesirable hydrogen peroxide intermediate will be largely diminished. Furthermore, the development of novel methodology permitting the **electrochemical CO_2-conversion** and production of small organic molecules or other chemicals can be envisioned. The expected advances in the area of the s**unlight-induced photoelectrochemical water oxidation and CO_2-reduction** (better efficiency and improved stability) are likely to be utilized toward development of new anodic and cathodic materials for **efficient electrolysis cells**. Large portion of the proposed studies refers to the basic characterization of the proposed nanostructured materials, determination of the experimental conditions including terms of activation and stabilization. Progress in concepts and designs of catalysts and electrolytic cells may lead to the effective and selective **formation of ammonia from nitrogen at higher than trace levels**.

This project involves the high risk – high gain type research (particularly with respect to nitrogen fixation). But even if not all catalytic systems would work as great as planned, the information gained could be crucial to the further **development of heterogenous catalysis of electrochemical reactions at low (ambient-type) temperatures.**