The main objective of the project is to fabricate good quality photonic materials based on porous anodic alumina (PAA) operating in a broad spectral range extending from visible (VIS) to the mid infrared (MIR) region. The photonic structures based on porous materials are usually one-dimensional (1D) photonic crystals built of many alternating low and high refractive index (RI) layers and the thickness adequate to obtain the enhancement of a selected wavelength (λ), as a result of constructive interference of waves reflected from the interface between the neighboring layers (the photonic stopband, PSB). The PSB is thus related to the wavelength ranges where the material demonstrates high reflectivity and low transmittance of light. The photonic structures, such as Bragg reflectors or optical microcavity, will be produced in the project by electrochemical methods under a proper selection of electrochemical synthesis parameters including type and concentration of electrolyte, application of the variable and cyclic anodization voltage, the number of cycles, etc. An important issue in the designing this type of structures is a precise control over the porosity of the alternating and subsequent layers, which translates directly into their n_{eff} (the effective refractive index) values. The larger the pore contribution, the closer is the n_{eff} to the value characteristic for air ($n \approx 1$). The larger the difference between the n_{eff}^1(low porosity layer) and n_{eff}^2 (high porosity layer) of the adjacent layers (refractive index contrast, n'_{eff}), the more light is reflected from the layer boundary, and the more intensive PSB at a given λ can be obtained. In the project various geometrical configurations of photonic structures based on PAA will be investigated in order to obtain an optimal optical performance (e.g. thickness of low and high porosity layers, the number of layers).

In the project, the basic research will be concentrated on designing new electrochemical strategies to produce PAA-based photonic structures with geometry adequate to generate photonic stopbands extended from VIS up to MIR region. An important innovative contribution to scientific fields including materials science and optics will be the production of large-interpore-distance (D_{int}) PAA-based photonic structures (D_{int} within 250-650 nm range) under new electrochemical conditions (new electrolytes, high voltage anodization, introducing modifiers into electrolyte, etc.). The larger D_{int} values will allow to fabricate PAAs of larger pore diameter (D_p). This, in turn, should widen the range of porosity manipulation of the alternating layers in order to optimize the n'_{eff} . The refractive index contrast will be also engineered by covering the pore interior with high refractive index materials (such as ZnS, ZnSe, TiO_2, etc.) using atomic layer deposition (ALD) technique which is characterized by high conformability (films of uniform thickness can be obtained on substrates with complex shape). Moreover, the photonic properties of selected PAA-based photonic structures (strong and narrow λ) will be optimize by application of noble metals (Au, Pt, etc.) which generate surface plasmon resonance (SPR) in a particular spectral range. Parallel optical analysis (reflectance or transmittance measurements) of the produced porous photonic structures and fundamental simulations will allow to find optimal synthesis parameters to obtain the research project objectives.

Currently, there is a huge demand for efficient, portable, and cost-effective optical sensors operating in a broad spectral range owing to the increasing number of potential hazardous chemicals in daily groceries and to a large threat caused by naturally occurring molecules, produced by microorganisms within our food. The photonic crystals are very often used as active optical components in this kind of sensors. The market is now dominated by the optical devices or components based on silicon and operating in the UV/VIS/NIR (UV- ultraviolet, NIR – near infrared) region. However, most of the dangerous gases and molecules possess their characteristic bands in the MIR spectral domain. Despite the great potential of the MIR region, the optical systems operating in this spectral domain are still under development. It is believed that the project will offer new technological solutions for production of innovative and affordable photonic materials with optical properties applicable in the VIS-MIR spectral range.