Human eye has special mechanism to sense a specific portions of electromagnetic (EM) wave spectrum, so called visible spectrum. In general language, we call this part of spectrum as light. Scientist are playing with light from centuries to understand the different phenomena of light. The most fascinating area of research is to control the direction of light in a medium. Naturally existing materials are limited with Snell's law and does not provides any special control to the flow of light. With the significant development in this area of research, we are now no longer limited with the natural response of the materials, in fact we can self synthesize new artificially designed materials so called *metamaterials*. Metamaterials are composed of repeated three dimensional (3D) unit cell structure in the plane. The response of metamaterials can be changed by changing the size of elements inside the unit cell. Although metamaterials provide a special degree of freedom to control the flow of light but, the 3D nature of unit cell make it difficult from implementations point of view.

Over a decade of development in the area of metamaterials, scientist came up with a new approach to use artificially designed 2D surfaces. The 2D surfaces are composed of tiny nanoantennas, which are specially distributed on the surface. This is known as $Metasurface$. When the light interact with metasurfaces, each nanoantenna can alter the amplitude, phase and polarization of the light locally. As a results, the intensity and direction of reflected or transmitted light is determines by the spatially distributed nanoantennas on a surface. Since the size and shape of the nanoantennas are of the order of wavelength, it is quite easy to fabricate such 2D metasurfaces with existing nanofabrication technology. Metasurfaces opened a new area of flat photonics components design which can replace the existing bulky optical devices like lens, prism, polarizer converter, and holography devices. The compatibility of metasurfaces with existing CMOS platform open the possibilities to fabricate multiple nanophotonics components on single chip.

The present state of art of metasurfaces based devices suffer a serious problem of single wavelength operation. Moreover, it also suffers the problem of poor efficiency. A more investigations are required to operate them over entire visible spectrum. In this project, our main goal is to investigate the possibilities of high efficiency broadband metasurfaces. Our goal of this proposal is to demonstrated the one application of broadband metasurfaces as metalens.

My PhD thesis is devoted to design and fabrication of ultrathin nanophotonic devices based on metasurfaces. The realization of this project will allow to finalize my PhD thesis. In previously published articles, I have already designed and demonstrated the high efficiency metasurfaces for color display application purposes. My previous skills in numerical simulation, experimental realization of devices are in close connections with the current proposal. Initial simulations results are motivation towards the realization of this project. The outcome of the project can lead to new flat optical devices, which allow to shrink the smart phone, camera and hand-hold wearable holographic devices. The new devices could be even 100 times thinner than the available one. This can predominantly impact to virtual reality devices such as Google glass, three dimensional (3D) projections, and Internet of things (IOT) devices. The main advantage of developed metasurfaces based lens will be the compatibility with the technology of existing electronics devices. This is complementary to normal optical lens which requires multi-step fabrication process to achieve low spherical and chromatic aberrations. Single step fabrication process will save production cost and time. Integration of metalens within the same chip will not only reduce the size of overall devices area but also reduces the significant additional hardware requirements. The metalens on chip can produce high quality aberrations free images at very high frame rate. Expensive high frames rate camera can be available at affordable price. The broader impact of these devices can be in the area of new methods of molecule sensing on chip, new non-invasive medical components design. Metasurfaces based ultra thin broad band metalens can replace the bulky parabolic reflector in spacecraft design and find the application in space mission. Apart from contribution to these innovative applications, the successful completeness of this project can lead to high impact publications and new idea for startups in the area of flat photonics components design.