The goal of the project is to develop a new research method, ultrafast stimulated Raman scattering enhanced by optical nanoantennas. The process called Raman scattering is a process in which a beam of light (usually laser light) as a result of illumination of a chemical substance partially scatters. That means it changes direction and at the same time changes its color slightly. This change in color is not accidental and depends very much on what the light has been scattered so that by measuring this light we can learn a lot about the substance. Unfortunately, this process is very weak and therefore hard to register. The optical nanoantennas can be used to increase the amount of scattered light. Optical nanoantennas are usually metal nanoparticles (metal particles about 1000 times smaller than the thickness of a human hair), which like radio antennas help to receive and transmit electromagnetic waves. In the case of optical nanoantennas, that electromagnetic wave is the visible light.

The stimulated Raman scattering method, enhanced by nanoantennas, is now in its infancy. Until now, it has been verified only that this method works and shows that the results of measurements with this method may depend on the type of optical nanoantennas and the measurement conditions of the measuring apparatus. It has also been shown that this method can be used to detect negligible quantities of substances with very high spatial resolution. However, it has not been verified precisely how the tested parameters of optical nanoantennas and measurement conditions affect the measured signal, what would enable understanding of these relationships and made it possible to include these factors to correct the measurements. In this project, we want to precisely define these relationships and develop the best optical nanoantennas for this kind of measurements. We also plan to perform computer simulations of various nanoantennas, what will allow us to develop the best nanoantennas. Thanks to these tests it will be possible to use this method routinely. In addition, we want to check whether the method of stimulated Raman scattering enhanced by nanoantennas can be developed with the ability to measure changes in samples occurring in very short times. Such changes can be, above all, chemical reactions that can take place even in unimaginably short time trillion times less than one second. Expanding this method in this direction would allow one to "see" how the chemical reaction proceeds.

There are already similar methods, but they have numerous drawbacks that substantially limit their use and the amount of information they can provide. However, the method proposed in this project allows these defects to be avoided and thanks to the use of optical nanoantennas it would allow testing only one chemical molecule at a time. That will have an impact not only on our better understanding of the world around us but also on chemical technologies because understanding how chemical reactions proceed is the first step towards better control and then using better, cheaper and greener products in production.