

Spintronics is a relatively new and rapidly developing field that takes advantage of the two fundamental properties of electron, spin and charge. The simultaneous control of spin and charge by electric and magnetic fields in spintronic devices has created an unprecedented opportunity for the construction of highly efficient and energy-saving devices for information storage and processing, as well as signal detection and measurement, and for the study of fundamental nanoscale effects and phenomena.

Spintronic tunneling sensors have unique design features and extensive measurement and detection capabilities. Tunneling sensors are nanoelements consisting of two ferromagnetic layers separated by a tunnel barrier. They are characterized by a resistance change depending on the mutual magnetization direction of the ferromagnetic layers, which can be changed by an external magnetic field, a perpendicular current or an electric field. They can be constructed with arbitrary resistance by changing the thickness of the tunnel barrier and the size down to the nanometer range. The sensors can be easily integrated with semiconductor technology, which ensures compact design and high reliability. Importantly, the sensors offer high sensitivity and nanometer spatial resolution. These features and properties make the sensors an important class of magnetic field sensors that can be designed to measure and detect a magnetic field over a wide range with high sensitivity, high spatial resolution (down to the nanometer range), and low power consumption down to the nanowatt range. As a result, the sensors have found a wide range of applications, from reading heads of hard drives, industrial and automotive sensors to biosensors.

Despite these unique features, high sensitivity and broad measurement and detection capabilities, the high magnetic noise of the sensors and its increase with sensitivity are serious obstacles to further improving their performance and use in demanding measurement and detection applications. The increase in noise means that increasing the sensitivity cannot improve the detectivity of the sensors, since the detectivity depends on both noise and sensitivity. This significantly reduces the measurement and detection performance of high sensitivity tunneling sensors and limits their applications. However, sensors with perpendicular magnetic anisotropy have been shown to have the potential to solve this problem. Therefore, **the aim of the project is to investigate the limits of the noise reduction and increase the detectivity of tunneling sensors by changing their magnetic anisotropy.**

Project research will focus on reducing magnetic noise, minimizing the noise increase, and improving sensor detectivity. The project will: (1) investigate the noise and detectivity of sensors with variable perpendicular anisotropy and exhibiting the effect of modification of the anisotropy with the bias voltage, (2) determine the limits of magnetic noise reduction and minimizing noise increase with sensitivity by modifying the perpendicular anisotropy, (3) determine the limits of improving detectivity by modifying the anisotropy with the bias voltage, (4) develop models of noise and magnetic field detectivity for sensors with variable perpendicular anisotropy and modification of the anisotropy with the bias voltage.

The project foresees excellent opportunities to go beyond the current state of the art by: (1) establishing the limits of noise suppression and improving the detectivity of nano- and microsensors, (2) determining the material structure and properties of sensors that will enable reduction of magnetic noise and minimize its increase with sensitivity, (3) determining the influence of anisotropy on properties of sensors that control noise and detection. These results will not only provide a deeper understanding of the noise limits and detection capabilities of tunneling nano- and micro-sensors, but also open up the possibility of using highly sensitive micro- and nanosensors in a range of new and challenging applications. The topic and scope of the research are in line with recent global trends in fundamental research on the use of spintronic phenomena and devices in highly sensitive measurements and detection and with nanometer resolution.