

Antiferromagnets that change colours when switched

They can be found in many places – in cars, power plants, toys, cabinets' locks, speakers, computers – but most people rarely notice them. They are magnets, which consist of ferromagnetic materials like iron, cobalt or nickel or their compounds. Our life would be certainly much more difficult without them and the large-scale nonvolatile data storage in electronic devices – much more expensive. The handling of magnets needs to be performed with care – too high temperature or external magnetic field may cause demagnetization which results in the loss of magnets' functionality. Therefore, there is a danger of loosing our favorite pictures, books or movies stored on a magnetic hard disc drive or demagnetizing a credit card, that will be permanently destroyed if heated or accidentally exposed to an external magnetic field.

However, there exist materials called antiferromagnets that despite of having magnetic atoms are not sensitive to external magnetic fields. Moreover, many of them have higher critical temperatures than ferromagnets and consequently may remain unchanged even when heated more than typical magnets. Application of such materials in data storage can make it much safer and additionally due to the dynamics of antiferromagnetic spins switching - much faster.

Unfortunately, the practical application of antiferromagnets is challenging. Their insensitivity to external environment also results in difficulties in controlling their magnetic state and consequently writing operations. It demands very high current densities, that cause the appearance of effects unfavorable from the point of view of reading operation, for example thermal inhomogeneities. Thus, reading signals of studying what is the magnetic state of an antiferromagnet are difficult to interpret. Precise interpretation can be performed only with the assistance of magnetic imaging techniques that usually exhibit significant complexity that limits practical applications.

This project research aims at development of a novel, optical technique of reading antiferromagnetic state. Obtaining and investigation of semiconductive antiferromagnets embedded in low dimensional structures - quantum wells or quantum dots is planned. Thanks to the synergy between antiferromagnet and semiconductor structures it will be possible to use methods typical for the latter like photoluminescence to study the spin state of antiferromagnet. So far, it has been demonstrated that is possible to conclude about the spin state of single magnetic ions in quantum dots or magnetic dopants in quantum wells basing on photoluminescence. However, this technique has not been explored for studying antiferromagnets. Therefore, the project has pioneering character.

The main research hypothesis is the existence of a difference in energy and polarization of emitted photons from low dimensional structure depending on spin state of antiferromagnet. To visualize it more clearly, we expect that the colour of luminescence of semiconductor structure will change depending on the information saved in an antiferromagnet, that is the direction of the spin that was set in preceding writing process. Such approach may allow for practical application of antiferromagnets in modern electronics based on spin manipulation called spintronics.