Obtaining and investigation of nanofilms of polymers with Single Ion Magnets attached

Jagiellonian University, Faculty of Physics, Astronomy and Applied Computer Science
Department of Advanced Materials Engineering

We live in the times of advancing miniaturization of computer memories. Hard drives several terabytes in capacity are available to almost anyone, while the famous Moore's law, formulated in the seventies of the twentieth century, states, among others, that the density of computer memory shall double each year. But who is behind this continuous development? The answer is: the scientists, who constantly work on developing new materials, and on the possibilities to apply those materials in computer industry. It was scientists who built the first computer in the mid-twentieth century, and now, only a few short decades away from that moment, the average citizen of our planet cannot imagine his or her life without a computer, a tablet, a smartphone, or all of the above. Meanwhile, it is worth to remember that every technological revolution has its roots in basic research, much like the studies that will be conducted within the framework of this project.

Low-dimensional molecular magnets are materials that constitute a large and important group of compounds within the still young field of molecular magnetism. A molecular magnet is, generally speaking, by definition a hybrid material, the magnetic properties of which have their source in single magnetic ions. The advantage of these materials over the classical magnets lies in their lightness, optical transparency, obtainment through chemical synthesis (molecular magnets are acquired using the 'bottom-up' approach, therefore, there practically exists a way to 'build' them out of single molecular 'bricks'), they may be diluted, placed within matrices, manipulated in practically any desired way.

The aim of the project is obtaining and characterizing a number of new so-called Single Ion Magnets based on cobalt(II) ions, the low dimensionality of which, and their small size, make them ideal candidates for placing in larger matrices. Such a Single Ion Magnet may be imagined as a single magnetic atom, cleverly placed in a chemical surrounding that allows stabilization of its properties. Such a magnet reacts to changes in magnetic field applied to it with a certain measurable delay (formally speaking, it exhibits slow relaxations of magnetization). The longer the time of relaxation (i.e. the time of reaction of such a magnet to the changes in the applied field), the better potential it has for being applied as, for instance, a byte of memory. During the project a series of cobalt(II)-based SIM compounds shall be synthesized and investigated, and the best candidates for further manipulations will be selected (selection criteria will be based on the relaxation time, on the value of the so-called energy barrier that has to be overcome in order to change the state of such a molecule, and on the temperature at which this phenomenon occurs, which obviously should be as close to room temperature as possible).

The next step will be 'attaching' such a molecule to a molecule of the chosen polymer. Polymers are very common materials (plastics used for the production of bottles, shopping bags, clothes, pipes or toys are nothing but polymers), and suitable for further processing. Polymers modified by us by placing a Single Ion Magnet within their structure will be investigated further in order to examine if the properties of the used low-dimensional magnets were modified by attaching them to the polymer. Next, by means of a series of methods, thin films of such modified polymers will be produced, and investigated further. Obtaining such a thin film using polymers containing Single Ion Magnets that still show slow magnetic relaxations shall be a significant step in the development of the new materials science. Of course, the polymer films obtained in the duration of the project will not yet be equal to a fully functional magnetic memory, they will nevertheless constitute progress in the right direction.

In summary, the project aims to bring the fascinating new materials, which Single Ion Magnets are, closer to their application as memory carriers. Producing a thin film of polymer with low-dimensional magnets attached will be an important step towards that. And possibly, in an even further perspective, however, not further than one generation, computer disks based on molecular magnets may become another point in the Moore's law mentioned in the beginning, and a part of our everyday life.