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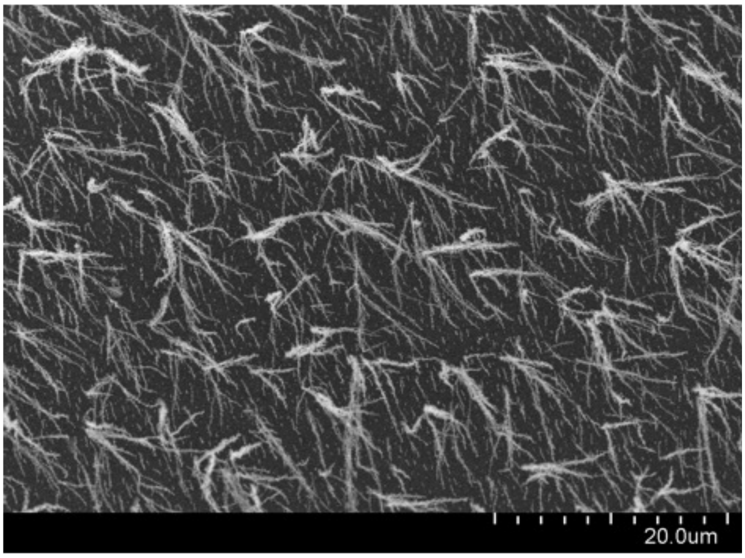
Magnetic Characterization of self-assembled magnetic nanoparticles

The understanding of magnetism has always been an important goal for humankind. Magnetic materials are part of our daily routines nowadays. They are essential parts in remote controls, speakers and in magnetic resonance imaging (MRI) in hospitals. They are key components in renewable energy technology with the ability to convert motion into electric power and replace fossil fuel energy sources.

The presented Bachelor project is in the field of nanomagnetism, a branch of physics that deals with the magnetic behavior of nanoscale objects. The nano- prefix means 10^{-9}, therefore nanoparticles are particles that are around 10^{-9}m. This Bachelor project investigates differences in the magnetic response of an ordered system, which organizes without external interaction, composed of nanowires made up from individual nanoparticles with a second sample with a random arrangement of nanoparticles. The material used is Magnetite (Fe_3O_4), a clear example of versatile material that works in MRI imaging, data storage, and cancer treatment. The structures are created for this project using an aerosol technique based on a Spark Discharge Generation (SDG), capable of producing particles with tunable composition, crystal structure, and narrow size distribution that can be deposited onto any substrate (see figure above). Magnetic self-assembled structures made up of nanoparticles could be used in catalysis, energy storage, and as building blocks for future high performing permanent magnets for green technologies such as electric vehicles and wind turbines.



Structure of deposited magnetites on a substrate. The presence of a magnetic field during the deposition leads to the formation of nanowires. Image taken with a scanning electron microscope.

This Bachelor thesis is a part of a larger project that is studying how the particle size, particle composition, and deposition parameters determine the material's final properties. To measure the magnetic properties of our samples, we use the Superconducting Quantum Interference Device (SQUID), a very sensitive magnetometer. The comparison revealed a clear difference in magnetization behavior between the samples and an increase in the remanent magnetization of 50% for the self-assembled system. It is clear that the system is temperature dependent, and when the system is at ambient temperature, the differences are less noticeable.

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