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Bottom-up fabrication of magnonic crystals utilizing polyoxometalates and block copolymers

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Magnonics is a new and emerging field of nanoscale science and technology. The goal of being able to produce magnonic devices is driven by the increasing needs of efficiency and speed of the technological devices our society thrives on. With the increase of energy consumption in the continuously advancing modern age, there needs to be ways in which energy is able to be produced either more sustainably, or the current processes need to be made more efficient. Spin-waves, otherwise known as magnons (hence the term magnonics), are generated when a magnetic disturbance is introduced into a spin-aligned material. This causes the aligned electron spins to precess, which in turn generates a detectable signal. Current data storage sites require a large energy consumption dedicated to cooling, and are often held in low temperature areas like the Arctic circle due to the high amounts of heat that are given off by electronic devices; in theory, magnonics has the potential to minimise the effects of heat since they are low energy systems.

To transport magnons in a controlled manner, spin-wave guides are required to direct the signal. Periodically structured magnetic materials are an important aspect in the study of magnonics as the formation of a band gap is required to control the allowed and forbidden magnonic states. It is also important to confine the spin-wave propagation to 2 dimensions in order to minimise the dispersion of the spin-waves once generated. In our research we are looking at using polyoxometalates as the magnetic materials and block copolymers as the structuring agents to fabricate spin-wave guides. Polyoxometalates were chosen as they are a promising candidate for magnonic wave guides, exhibiting structural and magnetic diversity.

In this work, we have used an amphiphilic block copolymer, poly(styrene-block-N-4, methyl vinylpyridine methyl iodide), to encapsulate polyoxometalate clusters in micelles. The highly anionic polyoxometalate species are able to undergo an ionic exchange reaction with the positively charged block of the block copolymer. We have demonstrated that the POMs used can bind to the block copolymer and form uniform micelles that can be deposited as a semi-ordered array onto substrates by spin coating. The resulting materials and films have been characterised at various stages along the way: FT-IR and TGA have shown that the POMs have been successfully incorporated into the polymer and that the amount of POMs incorporated can be controlled. SQUID results have shown that the susceptibility of the POMs is retained once incorporated into the polymer matrix. Dynamic light scattering has been used to find the optimal conditions for micelle formation with respect to both size and polydispersity. Atomic and magnetic force microscopy have shown that spin coating of the micelles onto a substrate forms ordered structuring of the micelles, and that these micelles do in fact show magnetic signals in their cores.

Speakers Gender

Male

Level of Expertise

Student

Do you wish to take part in the poster slam

Yes

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