The Future of Soft Robotics: 3D Printing Magnetic Shape-Memory Materials With Arbitrary Magnetisation

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The main goal of my project is to 3D print flexible objects with designed magnetisation. Such structures are capable of shifting geometry when the external magnetic field is applied and returning to their initial shape after the field is removed. They can find numerous applications in soft robotics, as they do not require electrical energy to function properly but instead rely on appropriate changes of the magnetic field. Due to the commercial unavailability of 3D printing filaments that are both elastic and ferromagnetic, one of the project goals was to develop a method of manufacturing composite filaments that remain flexible even after the mass fraction of the ferromagnetic infill exceeds 70%. To enable this, a uniform distribution and good wetting of the ferromagnetic particles had to be achieved, which was later confirmed by scanning electron microscopy. Multiple composite materials were studied, mainly formed by suspending varying mass fractions of hard and soft ferromagnetic infill microparticles in a polymer matrix. To optimise the morphology of used microparticles, ultrasonic atomisation was performed, followed by the microstructure analysis. Later, the magnetic properties of created composites were determined by vibrating-sample magnetometry and the influence of mass fraction of the hard ferromagnetic material on the remanent magnetisation was measured. Furthermore, the nozzle of a 3D printer was modified to enable magnetic-field-assisted filament extrusion. To validate the developed materials, numerous structures were 3D-printed that behaved as anticipated under the influence of a magnetic field, displaying vast possible applications in the fields from soft robotics to medicine.

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