A DEVICE TO PROGRAM THE MICROSTRUCTURE OF MAGNETIC NANOCOMPOSITES DURING DIGITAL LIGHT PROCESSING (DLP)

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Within the realm of 3D printing, smart and functional materials is a blossoming research field. Indeed, their functional properties pertain to the ability to interact with the environment, responding to various external stimuli. As a result, the combination of additive manufacturing with smart materials is opening up exciting possibilities for creating constructs that can actively react to stimuli. Besides, an ever-increasing attention is being given to the synergetic incorporation of fillers within the printable smart matrices so as to craft functional polymeric composite materials. This approach allows to expand the relationship between form and properties and offers an attractive strategy to generate objects with functional and/or reinforced properties.

Potential applications of 3D printed composite constructs are further expanded if the embedded fillers can be manipulated, assembled, or patterned during the printing process, so as to induce well-ordered and/or anisotropic microstructures. The primary interest in printing objects presenting a microstructure (oriented and organized) is generally associated with the possibility to obtain objects with enhanced mechanical and functional properties. However, the precise spatial control and arrangement of embedded fillers within a material during the printing process presents significant challenges, making this research area largely unexplored in both academic and industrial domains.

Here, we present a magnetic device that can be easily adapted to most of light-driven 3D printers, and that allows to generate a homogeneous magnetic field **B** adjustable in intensity and spatial directions during the printing process [1]. This device is based on the concept of the Halbach array, a specific arrangement of permanent magnets that significantly enhances the magnetic field on one side while virtually nullifying it on the other side [2]. This design allows the generation of a homogenous magnetic fields, whether in dipole, quadrupole, or even higher-order multipole configurations, within the printing region. By incorporating two concentric Halbach arrays in a cylindrical configuration alongside a solenoid, we enable the manipulation of a magnetic microstructure in the three spatial directions, i.e. $\mathbf{B}=(B_x, B_y, B_z)$. This, in turn, facilitates the self-assembly and spatial orientation of magneto-responsive fillers at each stage of the printing process.

After introducing theoretical and technical aspects of the device, several examples will be shown to demonstrate the capabilities of the devise to print magneto-responsive elements with spatially controlled microstructures.

References

[1] G. Rizza, A. Cosola, “A magnetic device configured to be installed on additive manufacturing apparatuses, enabling magnetically-assisted 3D printing of composite elements”, European Patent application No. EP23201535.4, patent pending.

[2] K. Halbach, IEEE Trans. Nucl. Sci. 26, 3882 (1979).