Nanostructured materials | Jožef Stefan Institute Ljubljana, Slovenia

SEMINAR

Wednesday, 11.3.2026, 13:00 , Kolar's Lecture Hall

Innovations in Magnetic-Field Assisted 3D Printing of Hard Magnetic Materials

Dr. Muhammad Shahid Arshad, Jožef Stefan Institute

Additive manufacturing (AM), or 3D printing, has significantly expanded the ability to design complex functional components with high geometric freedom and rapid prototyping capability. However, when applied to hard magnetic materials—such as Nd–Fe–B, Sm–Co, Sm-Fe-N, and ferrites—conventional 3D printing approaches rarely achieve their full magnetic potential.

A key limitation arises from particle alignment within 3D-printed structures. Traditional extrusion-based printing disperses magnetic particles randomly in a polymer matrix, resulting in isotropic bonded magnets with limited magnetic anisotropy. Because the remanent magnetization (Br) strongly depends on particle alignment along the easy axis of magnetization, random orientation inherently restricts magnetic performance.

Magnetic-field-assisted 3D printing addresses this limitation by applying an external magnetic field during material deposition. The field—generated by permanent magnets or programmable electromagnets positioned near the printing nozzle—exerts a torque on anisotropic magnetic particles, aligning them in situ before matrix solidification. This approach enables direct control over the internal magnetic texture during layer-by-layer fabrication.

Here, we report a field-assisted 3D printing platform that integrates programmable electromagnetic fields during deposition, enabling tailored particle orientation distributions throughout the printed structure. Such programmable control is particularly relevant for multipole magnet architectures used in electric motors and sensing applications, where spatial control of magnetization is essential.

To ensure industrial reliability and process validation, the system incorporates real-time, in-line micro-Hall probe scanning, enabling spatially resolved magnetic field mapping and alignment verification during fabrication. This monitoring strategy establishes a robust process–structure–property relationship, allowing immediate assessment of magnetic quality.

Additional technological developments include highly filled magnetic filaments, a filament monitoring system for quality control and consistent feedstock composition, and a specialized in-situ field-holder design that stabilizes particle alignment during printing. Together, these innovations advance magnetic-field-assisted additive manufacturing beyond proof-of-concept toward scalable production of anisotropic bonded magnets with complex geometries.

Kindly invited.