Poster | Material, processing, and characterization

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[P2] Sm-based Magnets & Nitrides

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[P2-49] Fabrication of Sm-Co-Fe-Cu-Zr and $SrFe_{12}O_{19}$ based permanent magnets by PIM-technology and stereolithography methods

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Additive manufacturing methods are actively introduced into existing technological processes of enterprises. Technologies such as stereolithography (SLA), selective laser melting (SLM), direct metal deposition (DMD) or laminated object manufacturing (LOM) allow to produce details with a high configuration complexity. For that purpose, a big variety of functional materials can be used in forms of filament, powder and foil. Main advantage of AM is ability to produce test sample or small series details in the short time. Otherwise, large scale production of parts with high shape complexity can be realized using the Powder Injection Molding (PIM) technology. The perspectives and the intensity of the development of the PIM-technology, which combines classical injection forming of plastics and sintering of metallic or ceramic powders, are determined by such advantages as the possibility of optimization of the design of the article, absence of constraints on complexity of its shape, increase of the density and strength of the preforms, material ratio about 97-99 % and high efficiency of the process. AM and PIM technologies promise much for the production of permanent magnets. PIM-technology has been successfully used for fabrication of Fe-Cr-Co permanent magnets with clear structure and high magnetic properties in comparison with investment casting technology. And SLM technology applied for building of one layer from Nd-Fe-B powder. This work dedicated to study possibility of making ceramic magnets based on cheap strontium hexaferrite $SrFe_{12}O_{19}$ and anisotropic Sm-Co-Fe-Cu-Zr magnets by PIM-technology and application of fine ferrite powders for fabrication of photopolymers and their usage for making complex shape samples by SLA method.Powders of strontium hexaferrite were obtained by ceramic method with grinding in ball mill. Cast of alloy with chemical composition (wt. %): 25.1 Sm, 48.8 Co, 18.1 Fe, 5.4 Cu, 2.6 Zr was obtained by vacuum induction melting and grinded forming powder with average particle size 27.4 μm. Strontium hexaferrite powder with average particle size 5 μm were mixed with photopolymer to produce material for SLA-technology. Powders based on the Sm-Co-Fe-Cu-Zr alloy and strontium hexaferrite (average particle size was 22 μm) were mixed with organic binder for preparation of granulate or feedstock for PIM method. Feedstock was used for obtaining first intermediate pieces called «green body»: granulate was compacted in an injection molding machine at the temperature close to melting temperature of organic binder. Feedstock filled with $SrFe_{12}O_{19}$ powder were pressed into injection molding machine

chamber without application magnetic field while Sm-Co powders were aligned inside «green bodies» by external magnetic field. Then «green bodies» were subjected to the removal of the binder during debinding stage forming second intermediate pieces called «brown body». Sintering of «brown bodies» filled with Sm-Co-Fe-Cu-Zr and ferrite powders was performed in vacuum furnace in argon and in muffle furnace in an oxidizing atmosphere respectively. 3D printing by stereolithography was possible with a maximum filling of photopolymers by 19 wt. % of strontium hexaferrite powder. Increase of the ferrite powder amount made polarization impossible even with powerful UV source. Magnetic properties of isotropic strontium hexaferrite permanent magnets obtained by PIM-technology were about 70 % of theoretical values: H_{CB} = 71.1 kA/m, B_r = 0.09 T. It occurred because of the low density of the samples and the presence of defects (cracks and pores). Combination of high density of Sm-Co-Fe-Cu-Zr permanent magnet (8.1 g/cm^3) and special heat treatment allowed to achieve magnetic properties close to requirements of technical documentation on industrial anisotropic magnets: H_{CB} = 743.8 kA/m, B_r = 0.97 T, $(BH)_{max}$ = 219.5 kJ/m^3.