Fabrication and swimming properties of magnetite coating micro-machines prepared by ferrite plating

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Owing to their potential for medical micro-robots which swim freely and wirelessly in living bodies for medical operations, spiral-shaped magnetic micro-machines driven by a magnetic field have attracted a great deal of attention [1]. To develop such a medical micro-robot, however, the magnetic micro-machines should fulfill the following requirements simultaneously: First, their size has to be in sub-millimeter scale so as to introduce the machines into blood vessels, for instance. Secondly, by choosing appropriate constitutive materials for ensuring the biocompatibility, they have to be stable enough chemically in living bodies. Thirdly, their mass density should be as light as that of blood. This paper presents completely solid-sate based magnetic micro-machines, which meets the above requirements at the same time. They were fabricated by combining the stereolithography technique, for constructing the template body in sub-millimeter scale, and the ferrite plating technique, for forming biocompatible think ferrite overcoat onto the template body.

For the micro-machine coated with Fe_3O_4, we performed for 533 min. The Fe_3O_4 coating micro-machine has the coercivity of 60 Oe and the magnetization of 0.181 emu at 10 kOe of three samples. This sample has isotropic magnetic properties and spinel structure as revealed by XRD. After we magnetized the samples perpendicularly to the direction of length, these light micro-machines swim in water by applying a rotational magnetic field. This micro-machin swims at rotation magnetic field intensity of more than 100 Oe and at rotation frequency of more than 20 Hz. As the micro-machine is magnetized by the rotation magnetization at over coercivity of 60 Oe, this micro-machine swims by induced with the rotation frequency. Magnetite thick film was plated uniformly at room temperature onto a resin-based tiny body with spiral structure. We fabricated the solid-sate based ferrite-coated micro-machines having the biocompatibility and the light mass density.

References

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