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Design and Control of a Hybrid Bidirectional Magnetic Levitation System

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For a typical magnetic levitation system (maglev), all electromagnetic actuators are used to generate attractive forces to levitate the system. However, electromagnetic actuators consume substantial amount of power because they use DC currents to compensate for the weight of the suspension system. An energy efficient hybrid magnetic levitation system is then proposed to solve this problem. The hybrid magnetic levitation system has bidirectional actuators which may control both vertical positions and horizontal positions. Permanent magnets are used as the source of bias flux to energize the working air gaps while the electromagnetic coils are used to supply control fluxes [1]-[2]. The magnetic circuits of the bias flux and control flux are not coincident such that low reluctance and efficient control flux path are guaranteed. Low control currents are then sufficient to levitate the suspension system. The schematic of a hybrid bidirectional maglev system is shown in Fig. 1. Figure 1 shows the flux distribution through each working air gaps driven by permanent magnets and electric coils.

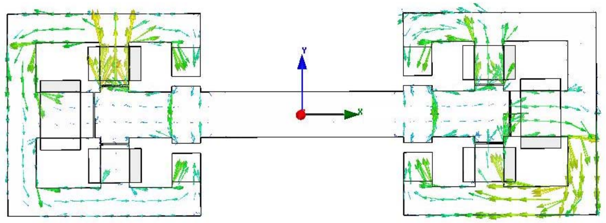

Fig. 1. Flux distribution of Hybrid Magnetic Levitation System.

The equivalent magnetic circuits for the maglev system are developed so that flux density to current relations on the maglev system is calculated. Based on the magnetic circuit analysis magnetic forces can be developed. Bias linearization for the nonlinear forces leads to current and position stiffness for the maglev system. The 3-D magnetic field model is constructed for the designed maglev system. The control system for the maglev system is developed to simulate the levitation control for vertical positions as well as horizontal positions. Simulations show that good levitation control is maintained.

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DP01

Numerical Formula of Depinning Field from Notches of Ferromagnetic Permally Nanowire

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Precise control of magnetic domain-wall(DW) position in ferromagnetic nanowire is important in the application for magnetic memory and logic devices.[1],[2] Geometric constrictions such as notches has been proposed for better DW stability and then, it becomes a crucial issue to design notches with optimizing the stability against thermal fluctuation. Here, we present an empirical equation of the depinning field from notches of ferromagnetic Permalloy nanowires. The notches with different geometrical parameters are realized as depicted in Fig. 1(a) and the depinning field is calculated by micromagnetic simulation(OOMMF)[3] It is revealed that the depinning field is in the form of an explicit function of the nanowire width and thickness as well as the notch depth and angle. The equation matches with all the micromagnetic simulation results within the accuracy of ±0.5 mT.

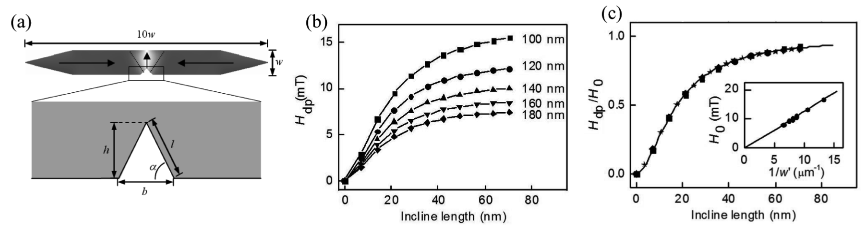

Fig. 1. (a)The geometry of the nanowire and notch in the simulation. (b) Depinning field with respect to the notch incline length for several different nanowire widths as denoted in the figure. The film thickness and the notch angle were fixed to $t = 5$ nm and $\alpha = \pi/4$. (c) Normalized depinning field. The solid line is the best fit by universal equation. Inset: The saturation depinning field H_0 vs. the inverse of effective width w'.

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