Study on scattering by SAW motor slider using FEM simulation

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1. Introduction
An extremely high performance surface acoustic wave (SAW) linear motor operating at 10 MHz has been already demonstrated. The maximum output force of 12 N, no-load speed of 1.5 m/sec and stepping motion of 0.5 nm were obtained\(^1,2\). However, the efficiency from the electrical input to mechanical output is still low. To improve the efficiency, an energy circulation driving method has proposed and demonstrated\(^3\).

For the energy circulation drive, forward scattering beneath a silicon slider was found to be a problem, due to the shift of phase relation. In this paper, numerical simulations were carried out to investigate the relationship between the phase shift and pre-load or projections of the slider using the finite element method. Several relationships were obtained: the relationship between the phase shift and contact area or friction coefficient.

2. Energy circulation and wave scattering
The energy circulation driving method is shown in Fig. 1; two phase driving IDTs and two unidirectional IDTs are used for driving and energy circulation. The circulated wave and the initially excited wave are superposed. It is very important that two phase driving wave and circulated wave are in phase to excite the Rayleigh wave efficiently.

The Rayleigh wave propagating beneath the slider, however, is scattered by slider projections shown in Fig. 2 with pre loaded condition. As the result, the phase of the wave after passing through the contacting slider varied from non-slider condition. This phase shift decreases the efficiency of the motor.

To improve the efficiency, no phase shift slider is desired. For the first step of the research, we carried out the numerical simulation using the FEM transient analysis including contact and friction problem; the mesh modeling is indicated in Fig. 3.

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3. Results of the simulations

3.1 Phase shift against preload and wave amplitude

Using the slider whose projection diameter was 50 μm and pitch was 100 μm, simulation was carried out. The phase shift against the pressure is shown in Fig. 4. Large pressure and small vibration amplitude caused large phase shift.

3.2 Phase shift and pitch of slider projection

The phase shift against the diameter of slider projection is shown in Fig. 5. The pitch was fixed to 100 μm. Large diameter caused large phase shift; large contact area caused large phase shift.

3.3 Phase shift against friction coefficient

To investigate the effect of friction, simulation was carried out in some values of friction coefficient; 0, 0.18 and 2. The slider projection diameter was 50 μm and pitch was 100 μm was used. The amplitude of the excited wave was fixed at 27.2 nm.

The phase shift against the pressure is shown in Fig. 6. Phase shift was not 0 when friction coefficient was 0, which did not generate friction force. Phase shift was about the same value at the 0.675 MPa pressure. However large friction coefficient caused large phase shift when the pressure was more than 1.875 MPa.

4. Conclusion

To investigate the relationship between the phase shift and the slider parameters, the FEM simulation was carried out using several sliders and several friction coefficient. As the result, it was found that large contact area caused large phase shift and projection pitch affected on phase shift slightly. Friction force affected on phase shift if the friction coefficient is large. However frictional force was, in case of realistic value, not the dominant factor for the phase shift.

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References