Implementation of Absolute Amplitude Measurement Function to High-Speed and Phase-Sensitive Laser Probe for RF SAW/BAW Devices

RF SAW/BAW デバイス用高速・位相感応型レーザプローブに対する絶対振幅測定機能の実装

Hikaru Takahashi†, Tatsuya Omori, and Ken-ya Hashimoto (Grad. School of Eng.,Chiba Univ.)
髙橋 輝†, 大森 達也, 橋本 研也 (千葉大院 工)

1. Introduction

The authors's group developed a high-speed and phase-sensitive laser probe system for diagnosis of RF SAW/BAW Devices based on the Sagnac interferometer (SI).[1] Its high-pass nature makes the measurement insensitive to low frequency vibrations and high-speed mechanical scan possible. On the other hand, this frequency dependence makes it complex to estimate the absolute vibration amplitude. So, only its relative value has been evaluated.

In contrast, the Michelson interferometer (MI) can quantify the absolute amplitude[2] but the high-speed mechanical scan is not applicable because MI is sensitive to low frequency vibrations, which cause fractuation of the optical path lengths.

This paper describes coaxial integration of the MI in the present system to evalute the absolute vibration amplitude without sacrifying the scanning speed.

2. Measurement Methods

Fig.1 shows configuration of the new optical system installed in the original laser probe. MI using 535 nm laser is integrated coaxially to SI using 635 nm laser, and their optical paths are separated by a dichroic mirror optically. The same detection electronics is given to both MI and SI independently. This arrangement allows us to measure the identical vibration pattern using two systems simultaneously. Furthermore, it gives a possibility to calibrate data captured by SI from those captured by MI. Note that no degradation was seen after integration in images captured by SI-based measurement.

Location of laser spots can be monitored by a CCD camera installed in the microscope tube. To stabilize MI operation, location of its reference mirror is adjusted by a PZT actuator. The low-frequency output of MI is used as the feedback signal for automatic control.

afya2242@chiba-u.jp

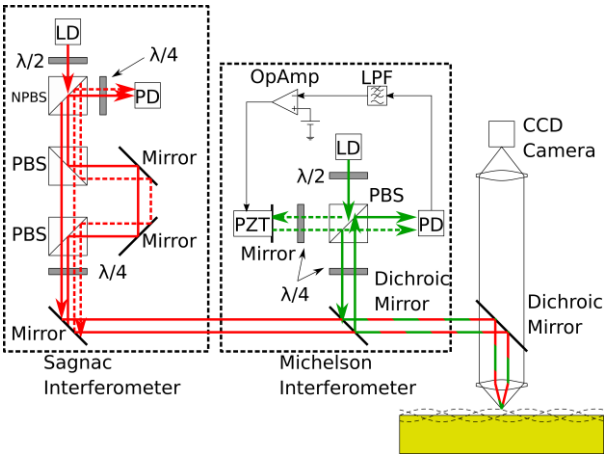

Fig.1 Optical System Configuration

Calibration data obtained from a small area are expected to be applicable to the whole area. If it is true, we can evaluate the absolute vibration amplitude from the SI output without scarifying high-speed and phase-sensitivity features of the original probe. The MI output must be related (calibrated) to the absolute vibration amplitude prior to the SI calibration. Here we adopt the technique described in [2] for the MI calibration.

3. Results and Discussion

To check correlation between MI and SI outputs, simultaneous measurements were performed over a whole area of a one-port SAW resonator on 42-LT.

Fig.2 shows the captured images at a resonance frequency of 678.8 MHz for the Rayleigh SAW. Both results are quite similar. Note that the scanning speed was reduced to 1/4 from usual SI-based measurement in this case for the MI stabilization. If not, the captured image will be disturbed significantly due to instability of the PZT-based feedback system.

For a more detailed comparison, one line data near the center was extracted from the amplitude data. **Fig.3** shows the comparison. Similarity of these two results are confirmed. Note that tiny lateral shift of 60 nm was observed in between two

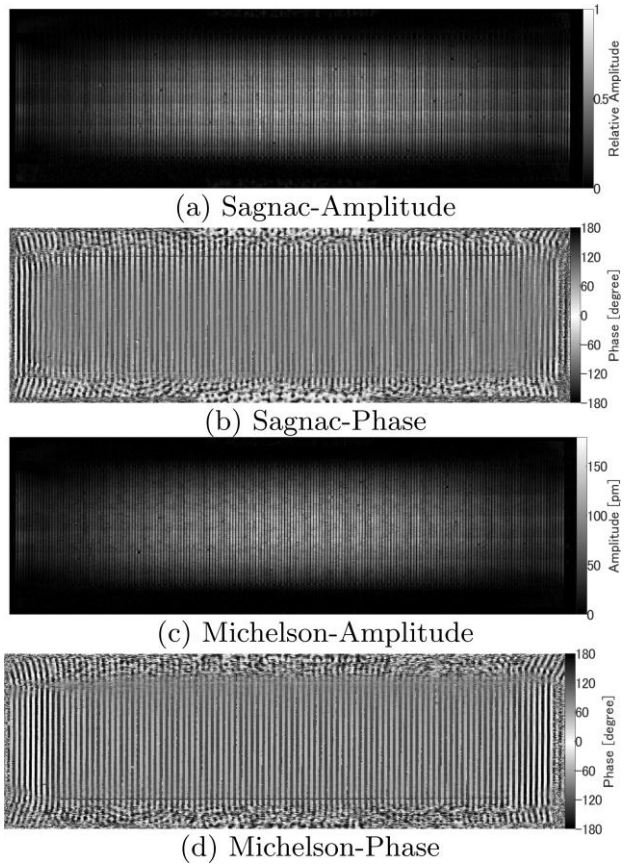

Fig.2 Captured images

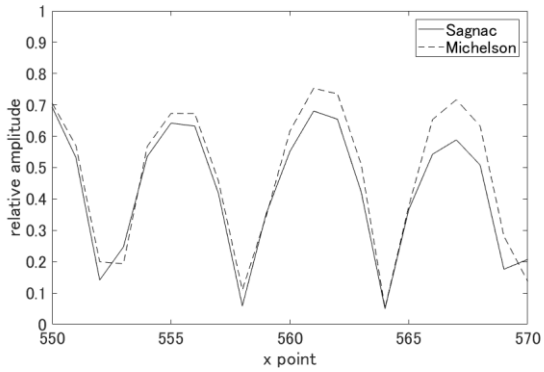

Fig.3 Measured amplitude of SI and MI outputs for one line.

data. This shift is due to misalignment of two laser spots.

Fig.4. shows a scattering plot between these two data after the correction. Good correlation and linearity are seen from this figure. In fact, a correlation coefficient of 0.95 is obtained. This result demonstrates that for the calibration, only one proportional coefficient is necessary and data for a tiny area are enough.

These results imply that the absolute vibration amplitude can be given to data captured by SI by the following procedure. (a) the measurement is performed by MI at a few representative points and determine a coefficient

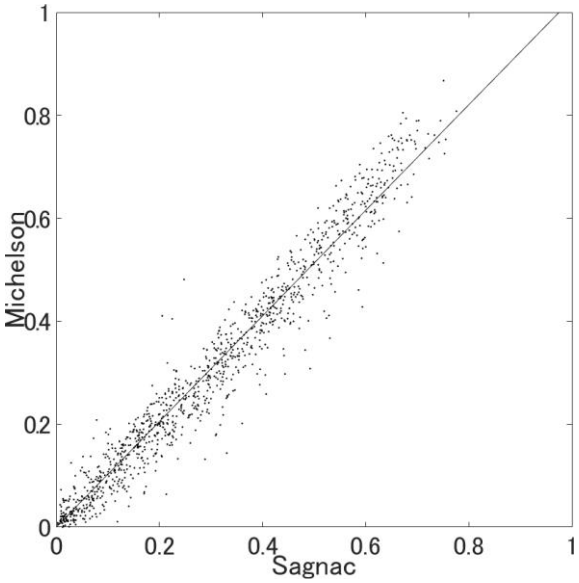

Fig.4 Distribution of SI and MI outputs after correcting miss alignment

between vibration and detected signal levels for MI. (b) vibration is measured for a small area (one line) by both MI and SI simultaneously and determines a proportional coefficient between the MI and SI outputs. The one line should include the point used in the step (a). (c) the whole area is scanned by SI and the obtained data are calibrated by the coefficients determined in the steps (a) and (b).

Note that amplitude responses given in **Fig.2** are calibrated in this way. Comparison with the full wave analysis was performed to check validity of this calibration. The result will be discussed near future.

4. Conclusion

This paper described coaxial integration of MI to the current SI-based laser probe system.

First, vibration image was captued for the idential sample by the MI and SI simultateously, and good correlation was obtained between their outputs. Then, the calibration procedure for the SI output was proposed.

Acknowledgment

This study was partly supported by a Grant-in-Aid for Scientific Research from Japan Society for the Promotion of Science.

References

1. K.Hashimoto, et al., IEEE Trans. Ultrason., Ferroelec., and Freq. Contr., **58**, 1 (2011) pp.187-194
2. L.Lipiäinen, et al., J. Appl. Phys., **108**, 11 (2010) 114510