Phase-sensitive and Fast-Scanning Laser Probe System for Radio Frequency Surface/Bulk Acoustic Wave Devices

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Use of laser probing systems is essential for the research and development of sophisticated radio frequency (RF) surface and bulk acoustic wave (SAW/BAW) devices which are widely used in various communication systems.

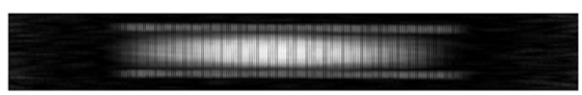
For the highly sensitive detection, the Michelson and Mach-Zehnder interferometers have been used. One of the drawbacks of these methods is sensitivity of the optical output to low-frequency vibrations. Therefore, they must be handled delicately and placed on a very heavy and huge anti-vibration mechanism. This problem limits their applicability only to professionals.

This talk reviews the current status of a laser probe developed by the authors' group. The system employs the Sagnac interferometer. Owing to its intrinsic high-pass characteristic, it can be insensitive to low-frequency vibrations. Thus, when micro-optic elements are used for its composition, a miniature and highly stable optical detector can be realized for high frequency vibrations without sacrificing sensitivity.

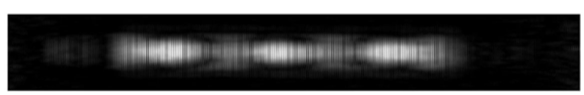
This interferometer was embedded in a confocal optical microscope and combined with sophisticated detection electronics and a fast and precision mechanical-scanner. The current system is applicable to characterize radio frequency (RF) surface and bulk acoustic wave (SAW/BAW) devices operating upto 6 GHz. The lateral resolution is better than 0.4 μm, and the focal depth is about 1 μm when a long working distance lens with high magnification (100×) is used. Detectable vibration amplitude is less than 10^{-12} m. A focus adjustment system was developed and installed for making the image in focus throughout the scanning area.

The system setup allows us to detect not only amplitude but also phase of acoustic vibrations. Thus, measured data in the real space (x-y) domain can be readily converted into the wavenumber (β_x-β_y) domain by the two-dimensional (2D) fast Fourier transform (FFT). Furthermore, we can re-convert the data in the β_x-β_y domain to the x-y domain by the 2D inverse FFT after selecting particular spectral component(s) numerically. This analysis offers various information; the types and characteristics of propagating waves, and where and how the waves are generated and propagated.

Fig. 1 shows measured examples of a one-port SAW resonator fabricated on the AlN/single-crystal diamond structure. Owing to fast mechanical scan, the measurement time was shortened to about 10 minutes for scanning 1500×200 (x×y) points with 0.2 μm step.



(a)At resonance (5,186MHz)



(b) At anti-resonance (5,203MHz)

Fig. 1 Measurement example.

The system has been used for the characterization of various RF SAW/BAW devices by many academic and industrial partners. Through the collaboration, the system has been evolved year by year, its effectiveness has been demonstrated, and is well recognized all over the world.