3P1-1
Proceedings of Symposium on Ultrasonic Electronics, Vol. 37 (2016)
16-18 November, 2016

FEA of Lamb wave in anisotropic plate

Donghyun Kim†, Young H. Kim
Applied Acoustics Lab, Korea Science Academy of KAIST

1. Introduction

Lamb wave is generated by alteration and sequence between shear and bulk wave. The dispersion curve of various modes can be calculated if the shear velocity and bulk velocity in the plate is given. However, anisotropy can cause difficulties in calculation due to the difference in orientation of group and phase velocity.
A different approach is needed for anisotropic materials. Generally, experimental approaches are performed. However, experimental approaches oblige considerable measure of time and effort. Excluding the restraints and inaccuracy of measurement, beam-skewing is the most crucial factor that adds difficulty to research concerning anisotropy.
There were few previous researches concerning lamb wave propagation in silicon single crystal plate. In the research, beam skewing wasn't put to consideration. The beam skewing and experimental barriers left imperfections to the result. Which can be highly improved by approaching with computer simulation.

2. FEM Simulation

When studying lamb wave using a common transducer, many loops have to be made with its standards placed on the frequency, incident angle, rotational angle of anisotropic plate, etc. Transition to LALFT (Large Aperture Line Focusing Transducer) yet requires loops based on frequency, defocusing length, rotational angle of anisotropic plate, etc. These time consuming process can be reduced into a single FEM simulation, which is more precise and accurate.

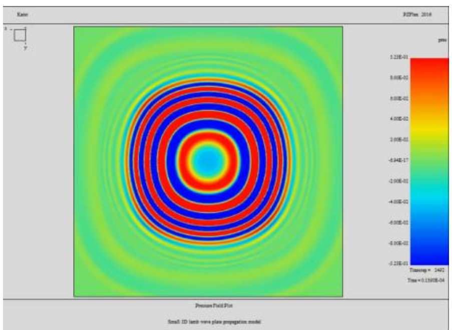

Fig. 1 Pressure plot during FEM simulation in a si100 plate

In this research, computer simulation was used to emulate a pressure load on the center of an anisotropic plate. PZFlex was used for the FEM simulation program. The anisotropic plate is 200mm wide, 200mm long, and 1.5mm thick. Pressure was loaded on a square of 5mm wide, 5mm long at the center of the top of the plate. The pressure was a cycle of a sinusoidal wave with frequency of 0.3MHz. The mesh was 150 elements per wavelength with the exception of z axis, which was 300 elements per wavelength. The pressure from points of equivalent distance from the center, and different angles/faces were obtained.

3. Results

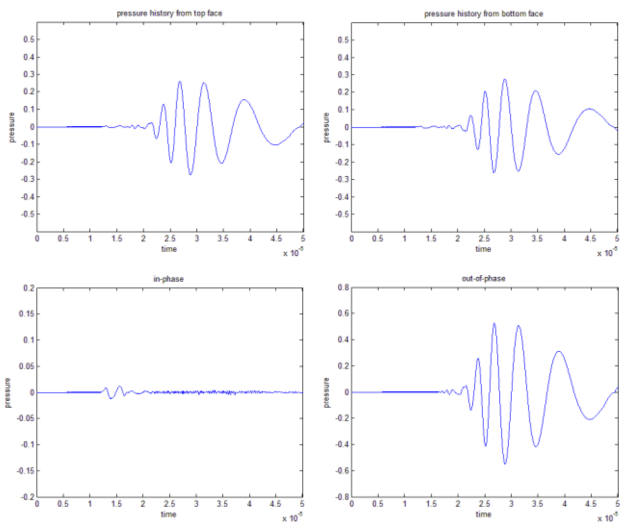

Fig. 2 The original pressure history from top and bottom faces of same orientation
S mode and A mode separated through in-phase and out-of-phase sequencing

A minor difference is apparent from the pressure histories of the same face and different orientation. The first peaks of S mode and A mode are differently oriented for each orientation, which is clearly an indication of anisotropy.

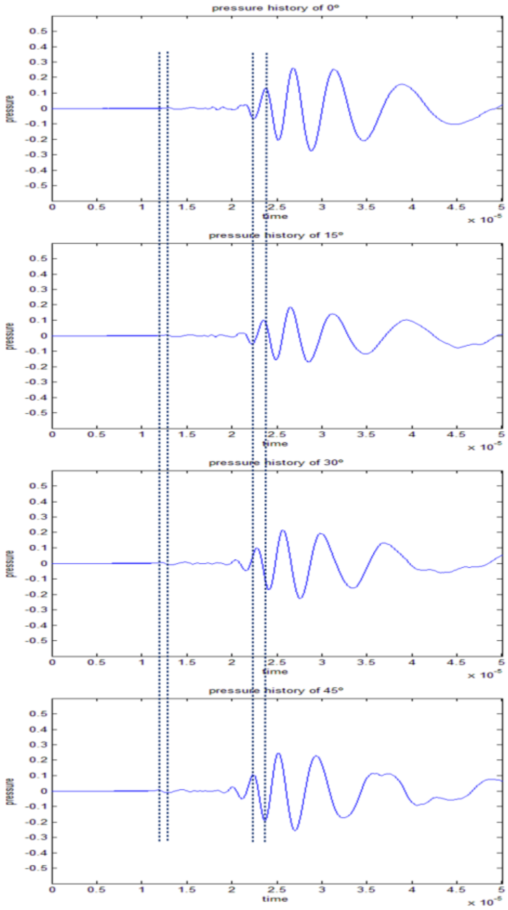

Fig. 3 Pressure history from the same side and different orientations

The obtained pressure histories were analyzed through slowness curve and STFT. The S mode and A mode is isolated by sequencing the pressure history from either faces in-phase or out-of-phase. This allows independent study on S mode and A mode.

The slowness curve is gained by identifying the peaks of each mode in each angle. The distance from the center is equivalent, allowing direct transition between time of arrival and slowness. Anisotropy was recognized from slowness curve for either modes.

The STFT for pressure history can be inversed into dispersion curve. The dispersion curve for each angle of anisotropic plate were obtained and correlated with the dispersion curves calculated by using the shear and bulk wave velocity from each angle and assumption that the plate is isotropic. The inequalities were insignificant due to the resolution issues with STFT.

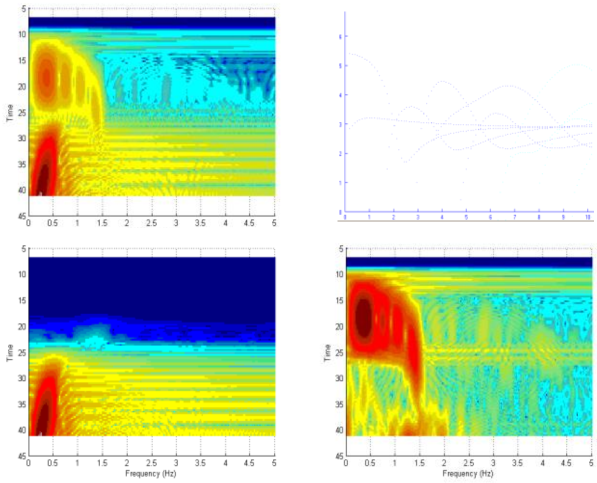

Fig. 4 STFT of unprocessed pressure history and in-phase and out-of-phase sequenced pressure history compared with a general dispersion curve of an Lamb wave

4. Conclusion

Study on Lamb wave propagation in an anisotropic plate using FEM simulation was successfully accomplished. The dispersion curves for each orientations were obtained. The variations of propagational characteristics differed based on the orientation of the crystal. The dispersion curves for each orientation of an anisotropic plate is achieved.

Acknowledgement

This work was supported by the Korea Science Academy of KAIST with funds from the Ministry of Science, ICT and Future Planning.

References

1. Gyeongwon Yun *et al*, Comparison of slowness curves of Lamb wave with elastic moduli and crystal structure in silicon wafers (2013 IEEE International Ultrasonics Symposium (IUS))
2. Jaewon OH *et al*, Study on Ultrasonic Wave Propagation in Anisotropic Plates Using Large Aperture Line Focusing Transducer (2015 NDT in progress)

Donghyun Kim: ggjjvb@gmail.com
Young H. Kim (corresponding author): yhkim627@kaist.ac.kr