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Theoretical consideration of V(x) measurement method using the line-focus-beam ultrasonic-material-characterization system

直線集束ビーム超音波材料解析システムを用いた V(x)測定法の理論的検討

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1. Introduction

The line-focus-beam ultrasonic material characterization (LFB-UMC) system is capable to measure accurate phase velocity of leaky surface acoustic wave (LSAW) propagating on a water-loaded specimen surface [1, 2]. It is very useful for evaluating material homogeneity and several demonstrations were conducted [3, 4]. LSAW velocity is determined from the oscillation interval Δz of the transducer output V(z) curve [**Fig. 1**(b)] obtained by scanning the LFB lens along z-axis direction as shown in Fig. 1(a). However, it takes much time for measurements in such a case of 2D-mapping over the whole specimen surface because the V(z) curve measurement is necessary at point by point on the specimen surface. So, we proposed a new method for measuring material homogeneity using fast scanning V(x) method with the LFB-UMC system. In this paper, we theoretically investigated how to determine the measurement condition of the V(x) method.

2. Concept of V(x) Measurement Method

The concept of the V(x) measurement method is shown in **Fig. 2**. The measurement procedure of the V(x) method is as follows; (1) measurement of a V(z) curve at one chosen point, (2) determination of defocus position z_d, (3) measurement of V(x) scanning the LFB lens along x-axis direction keeping the lens at $z=z_d$, (4) estimation of *dz* corresponding to the output level change ΔV(x) from the reference V(z) curve, and (5) calculation of LSAW velocity using *dz*. The key point of this method is how to determine the defocus position z_d. The z region where the output level monotonically increased or decreased were selected from the V(z) curve measured as shown in Fig. 2. However, waveform of the V(z) curve changes depending on the characteristics of the material. Because the influence of wave attenuation might be significant, we considered the influence in the next section.

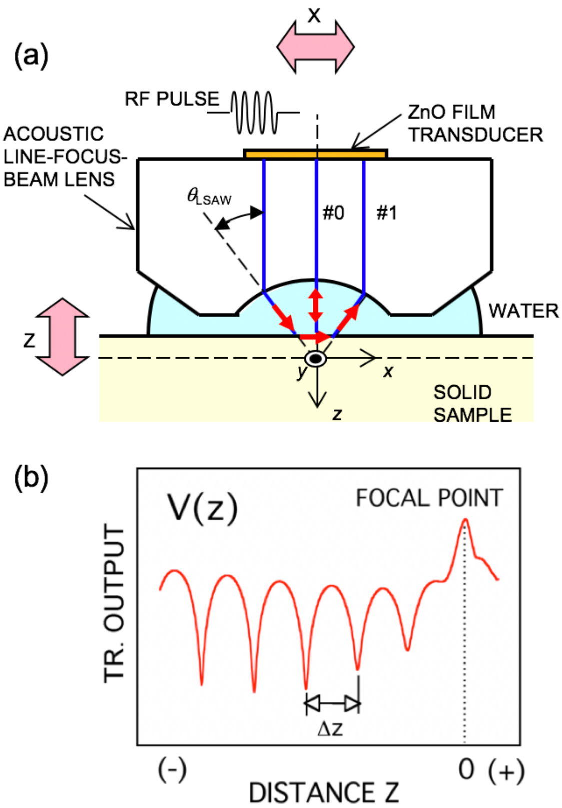

Fig. 1 Cross-sectional geometry of the LFB ultrasonic device describing the measurement principle (a), typical V(z) curve obtained as transducer output (b).

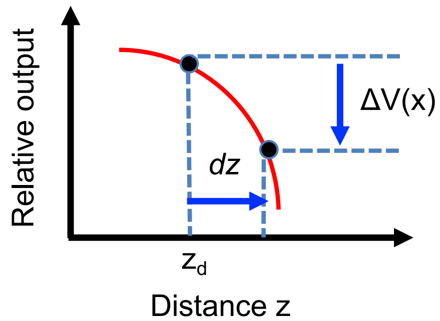

Fig. 2 Concept of V(x) method. Solid line: a part of a V(z) curve. z_d: defocus position when scanning V(x) measurement.

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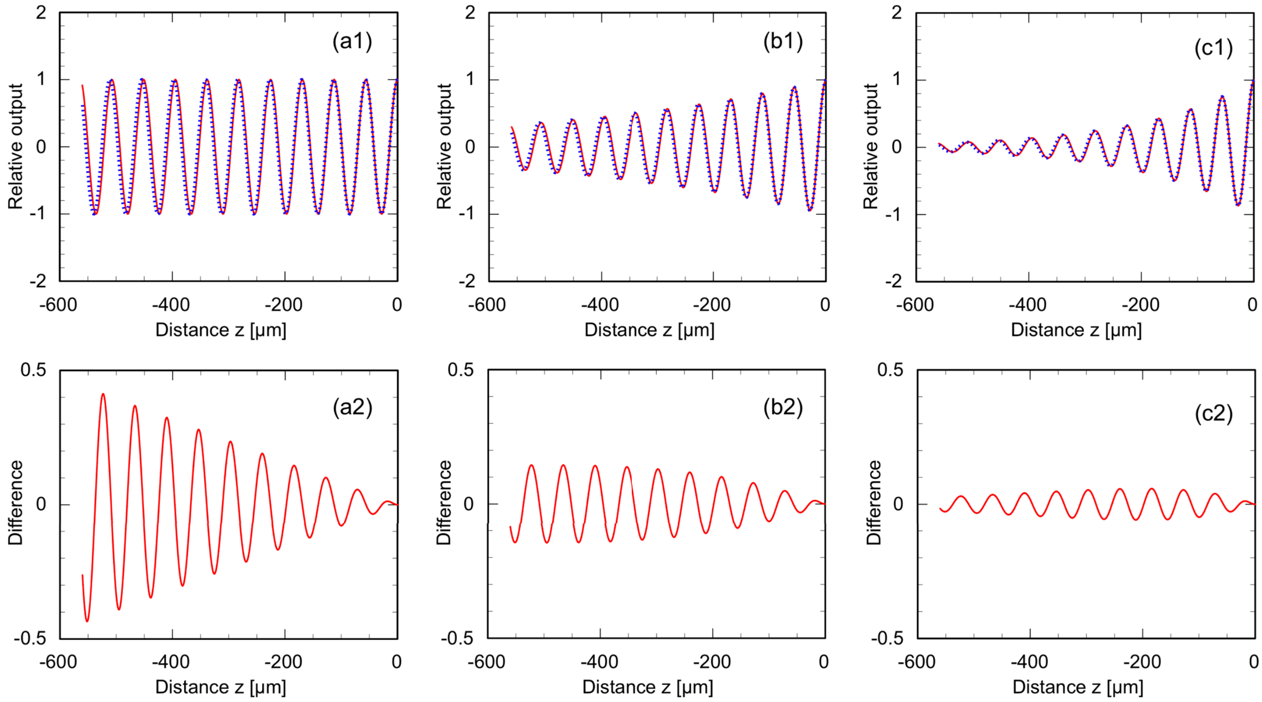

Fig. 3 Interference component of V(z) curves with different wave attenuation (upper). Interval of the waveform corresponds to LSAW velocities of 3000 m/s for solid line and 3010 m/s for dotted line at 100 MHz. Lower figures are difference between the solid line and dotted line in the upper figures. Wave attenuation α: (a1) α=0, (b1) α=1/500, (c1) α=1/200 naper/μm.

3. Numerical Calculation and Discussion

Fig. 3 is numerically calculated result of interference component of V(z) curves with different wave attenuation. In Fig. 3(a2), the difference increases with z position decrease (larger defocus position). On the other hand, in Fig. 3(c2), the maximum difference appears at around z=-200 μm. Therefore, this suggests appropriate defocus position z_d exists depending on the wave attenuation. The peak difference of lower figures in Fig. 3 were extracted and plotted as a function of distance z in **Fig. 4**. The appropriate defocus position z_d can be determined by selecting z position where the difference is the maximum in Fig. 4.

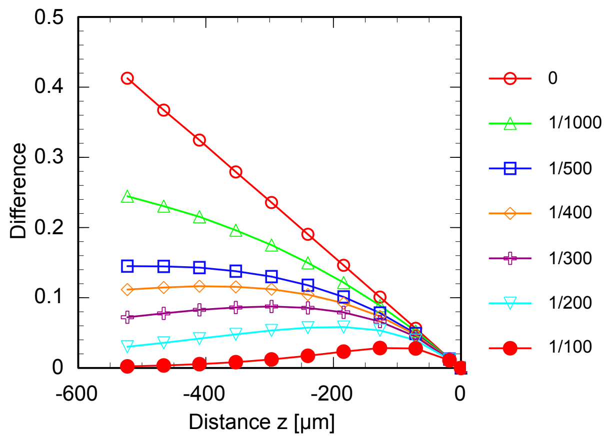

Fig. 4 Peak difference for the waveforms with different wave attenuation extracted from the lower figures in Fig. 3.

4. Conclusion

We theoretically investigated how to determine the measurement condition (especially defocus position z_d) of the V(x) method. Through the numerical calculation of interference component of V(z) curves with different wave attenuation, we suggested that appropriate defocus position z_d existed to obtain more accurate measurement data.

References

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