Study of Ultrasonic Behavior of Salol near Melting Point Using Interior Transducer-Type Cell

Proceedings of 12th Symposium on Ultrasonic Electronics, Tokyo 1991
Japanese Journal of Applied Physics, Vol. 31 (1992) Supplement 31-1, pp. 60–62

Study of Ultrasonic Behavior of Salol near Melting Point Using Interior Transducer-Type Cell

Hiroaki KAMIOKA

Department of Physics, Faculty of Engineering, Gifu University, Yanagido, Gifu 501-11

(Received December 4, 1991)

An interior transducer-type cell was designed for measuring the ultrasonic velocity and attenuation of a sample under both conditions of melting and solidifying processes with observing the condition of the sample from outside the cell. Using the cell, the sound velocity and attenuation of Salol were measured in the range between the room temperature and 80°C, including the melting temperature. The results for the ultrasonic behavior in the vicinity of the melting point are reported and siscussed.

KEYWORDS: melting point, ultrasonic cell, Salol, sound velocity, ultrasonic attenuation, supercooling, solid phase, liquid phase

§1. Introduction

The study of the properties of materials near the melting points of the solid phase and near the solidifying points of the liquid phase has been a matter of concern in the fundamental research and the practical application.[1] By present author, two kinds of ultrasonic cell for the ultrasonic velocity and attenuation measurements near the melting point were lately designed for continuous measurement from the solid phase to the liquid phase.[2,3] By using these ultrasonic devices, he studied the elastic and anelastic properties of pure metals,[4,5] alloys[6,7] and Salol[3] at their melting points, and reported many experimental results useful for understanding of the melting phenomenon. However, there are problems in the definiteness of the results, namely the results have sometimes affected by the shape of the ultrasonic cells, especialy the position of the transducer. Therefore, a cell was newly designed and it was called "an interior transducer-type cell".

The objective of the present study was placed on the measurements of sound velocity and attenuation in the process of melting or solidification, and on comparing the results with our previous data of Salol.[3]

§2. Experiments

The transducers in our previous cell[2] were located on the inner surface of it. In the interior transducer-type cell used in present work, however, the transducers are enclosed by the sample. The reason is that there are some doubts in the support of specimens and the stability of experimental conditions. The cross-sectional view of the ultrasonic cell is shown in Fig. 1. The main part of the cell is made of glass. The sample is prepared in the inner space 3 cm in diameter and 7 cm in length. Two glass pipes 15 cm long and 1 cm in diameter are attached to the main body of the cell, and the melted specimen is poured through one pipe into the cell.

The full details of measuring the temperature variation of sound velocity and of sound attenuation are described in the previous paper.[3] The state of the sample in the glass cell was observed or photographed through the glass wall of the water bath.

§3. Results and Discussion

Figure 2 shows the temperature dependences of the sound velocity and the sound attenuation in Salol during the melting and solidification processes. The hysteresis

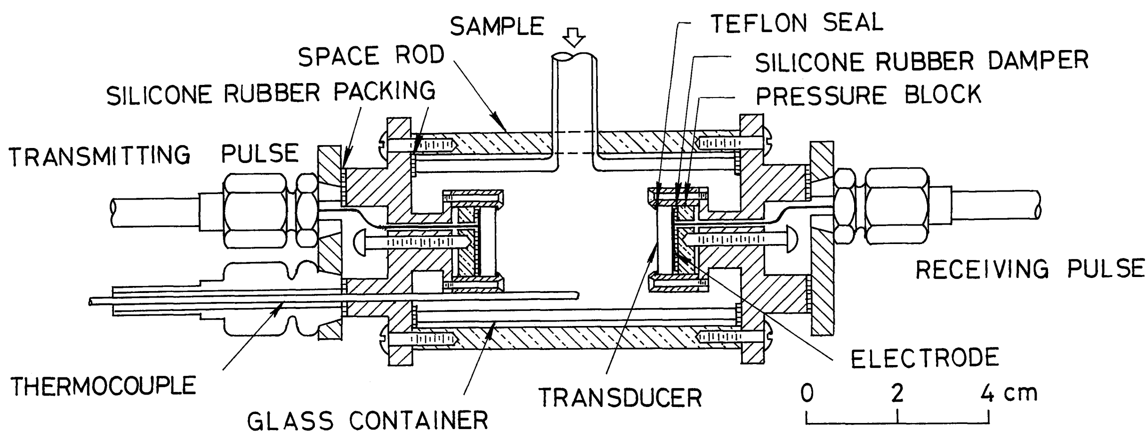

Fig. 1. Cross-sectional view of interior transducer-type cell.

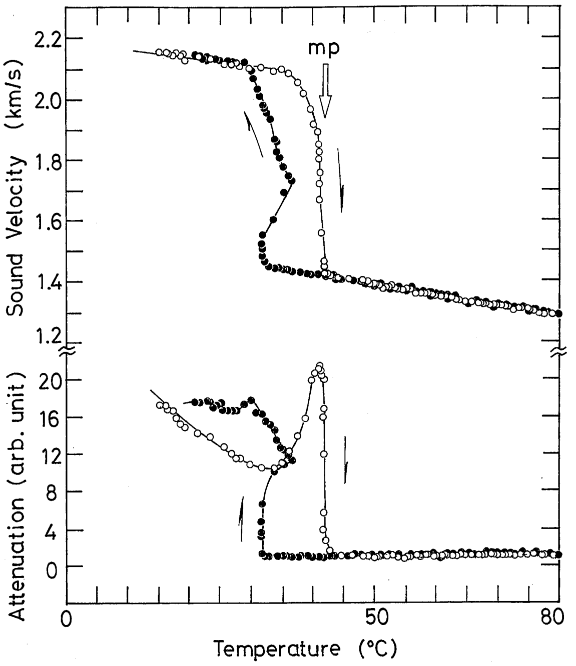

Fig. 2. Dependences of sound velocity and attenuation of Salol on temperature in the range of solid and liquid states.

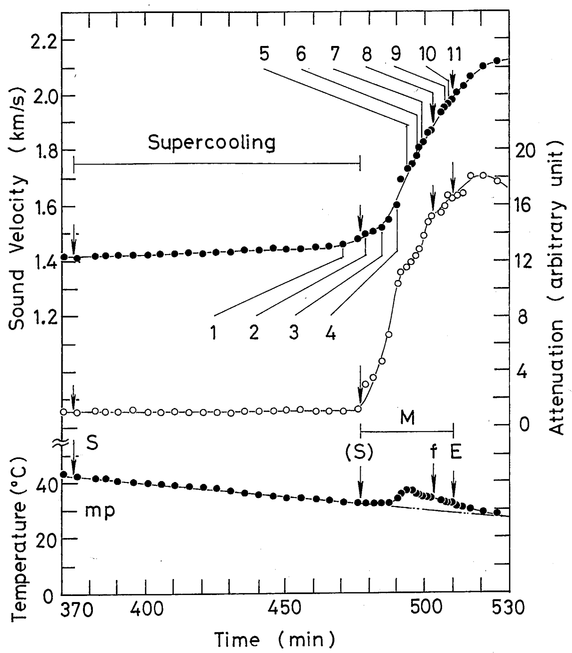

Fig. 4. Changes of sound velocity, attenuation, and specimen temperature with time in the cooling process.

results from the supercooling of the liquid melt during the solidification. During the solidification, the temperature of the sample in the state of supercooling shows a temporary increase.

Figures 3 and 4 show the change of the specimen temperature, sound velocity and attenuation with the lapse of time during the melting and the solidification processes. In Fig. 3, the sample temperature showing a constant value is the melting temperature, 42°C, and the notation S shows the starting point of the melting, and E

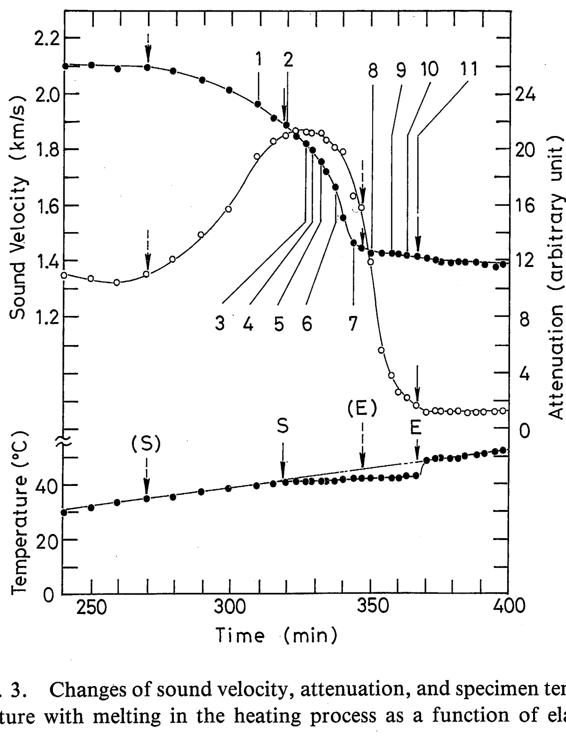

Fig. 3. Changes of sound velocity, attenuation, and specimen temperature with melting in the heating process as a function of elapsed time.

corresponds to the finishing point of the melting. The changes of the sound velocity and the attenuation, however, seem to begin and end at temperatures indicated by the arrows (S) and (E), respectively. In Fig. 4, on the sample temperature curve, the arrows S (42°C, melting temperature) and f correspond to the starting and the finishing points of the solidifying. However, in the region between S and (S), the sample is in the liquid state. On the other hand, in the region M between (S) and E, the solid and the liquid phases coexist.

The appearance of the melting phase in Salol during the melting and solidification processes is shown in Fig. 5. The photograph number corresponds to that shown in Fig. 3 or 4. The part surrounded by dotted lines shows the path of the acoustic beam. The dark area of the photograph shows solid phase, and the white area liquid phase. From Figs. 3 and 5, it can be seen that the sound velocity during the melting process shows steep decrease with the increase of the volume of the melt phase between S and E, and that the attenuation shows peak. Noticeable changes of velocity and attenuation are, however, seen even before the starting point of the melting S, and as shown in Figs. 4 and 5 even after the finishing point of the solidification process E. These facts suggest that the sound velocity and the sound attenuation remarkably change in the solid near the melting point.

The changes of the sound velocity and attenuation with the melt fraction are shown in Fig. 6. The volume fraction of melt in the ultrasonic beam region were determined from the photographs shown in Fig. 5. In Fig. 6, S and L indicate the values of the velocity and attenuation at the point (S) and E, respectively. As can clearly be seen in Fig. 6, the remarkable changes of velocity and attenuation occur even in a solid of melt fraction 0% near the melting point. The results of the measurements obtained here are in accordance with the previous results.[3] The

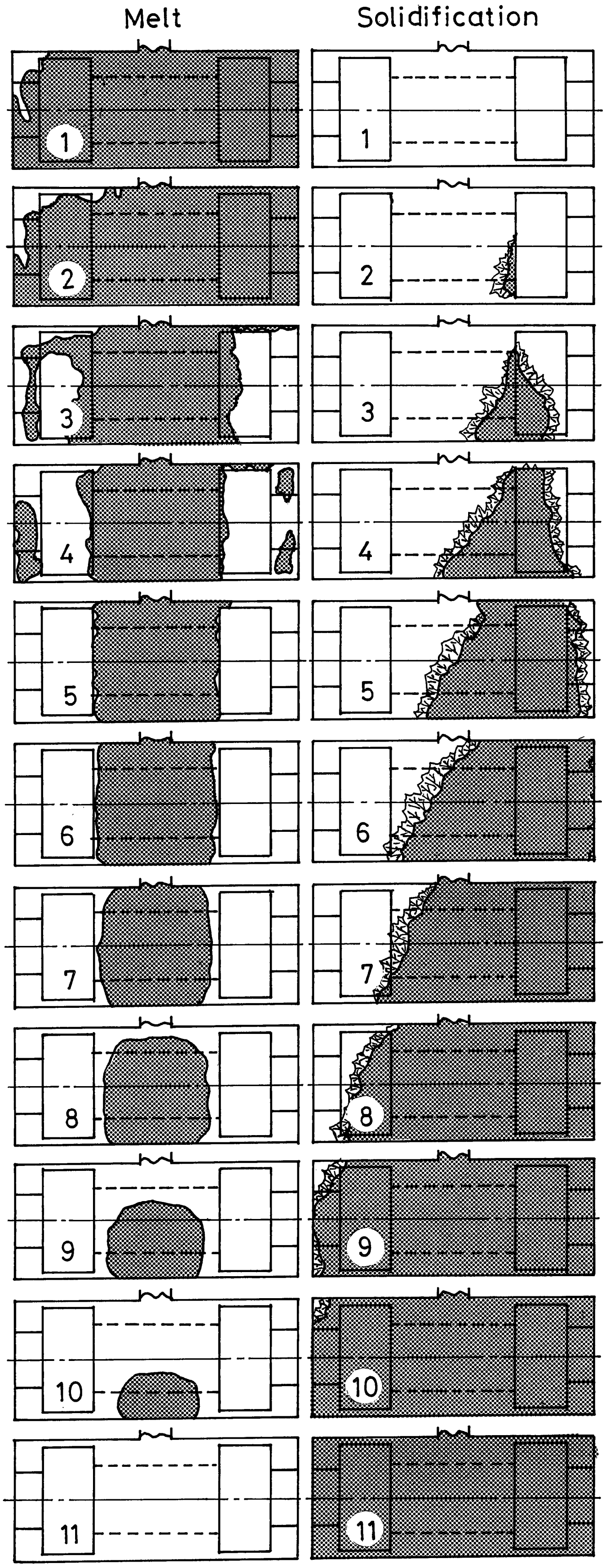

Fig. 5. Change of state of Salol during the melting and solidification processes.

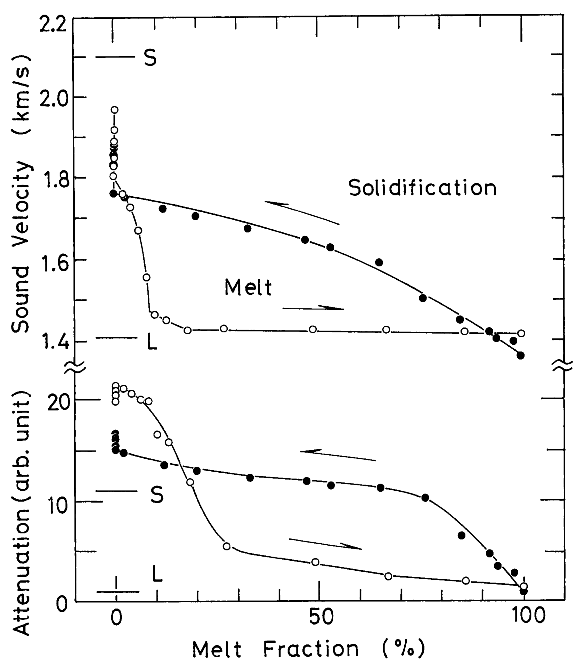

Fig. 6. Changes of sound velocity and attenuation in Salol as a function of melt fraction.

fact shows that the difference in the shape of the cell has no influence on the results of the measurements.

§4. Conclusion

The melting and solidification of Salol were investigated using the interior transducer-type cell. The results were the same as those observed in the previous study by the other type of cell. Therefore, the following conclusion can definitely be drawn. Namely, remarkable changes in the sound velocity and attenuation are observed even before the melting starts, and also after the completion of the solidification. The fact suggests that some structural change is occurring in solid phase near the melting point.

References

1) S. M. Stishov: Sov. Phys.-Usp. **17** (1975) 625.
2) H. Kamioka: Jpn. J. Appl. Phys. **22** (1983) 437.
3) H. Kamioka: *Proc. 11th Symp. Ultrasonic Electronics, Kyoto, 1990*; Jpn. J. Appl. Phys. **30** Suppl. 30-1 (1991) 34.
4) H. Kamioka: J. Phys. Soc. Jpn. **52** (1983) 2433.
5) H. Kamioka: J. Phys. Soc. Jpn. **52** (1983) 2784.
6) H. Kamioka: Jpn. J. Appl. Phys. **23** (1984) 154.
7) H. Kamioka: J. Phys. Soc. Jpn. **53** (1984) 1349.