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Acoustic field and pressure dependences of sonoluminescence

ソノルミネセンスの音場・音圧依存性

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1. Introduction

Sonoluminescence (SL) increases as acoustic power increases, shows a maximum, and finally quenches. The reason of this effect was suggested as a decrease in active bubble population, a generation of bubble clusters, or surface deformation of sample liquid[1,2]. However, there has been very few experimental works elucidating this mechanism. We aim to clarify the mechanism of the power dependence of SL under sound fields having free end or fixed end.

2. Experimental

We used krypton-saturated water, which was contained in a rectangular cell made of quartz glass (65x65x90mm). Ultrasonic frequency used was 84 kHz. In order to establish standing waves condition, a liquid height was adjusted to 4 and quarter wavelength for the free-end, and 4 wavelengths for the fixed end. We also observed free-end condition in which surface was covered with thin PET film (0.1mm). In the case of fixed end, surface was covered with a stainless-steel plate with a thickness of 17mm which is equivalent to quarter wavelength. SL was captured with a digital camera (Canon EOS6D) with the high sensitivity of ISO 10000 and the exposure time of 30 s. Shadowgraph of acoustic bubbles was observed using a high-speed camera (Shimadzu, HPV-2) with the speed of 63 k fps. Movement of the whole acoustic bubbles was observed using a high-speed camera (Casio EX FH20) with the frame speed of 420 fps.

Furthermore, we measured acoustic emission spectra in the case of free end using a broadband PVDF sensor.

3. Results and discussion

Fig.1 shows the power dependences of SL images for three cases of boundaries. The SL patterns were compared with the cases of free end and fixed end. Only in the case of stainless-steel plate, a light emission was seen at the liquid-plate interface, confirming that the interface is the rigid boundary.

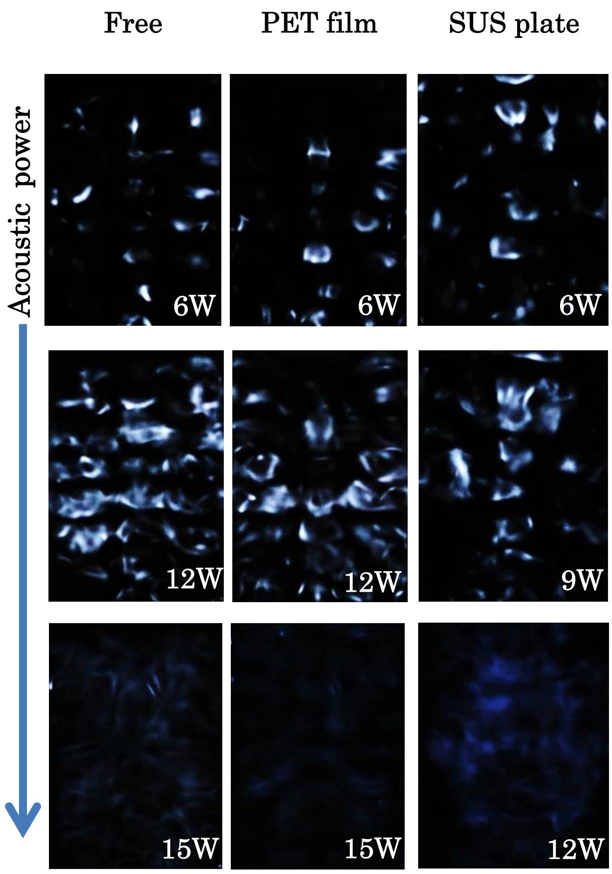

Fig.1 Power dependences of SL images for three cases of boundaries

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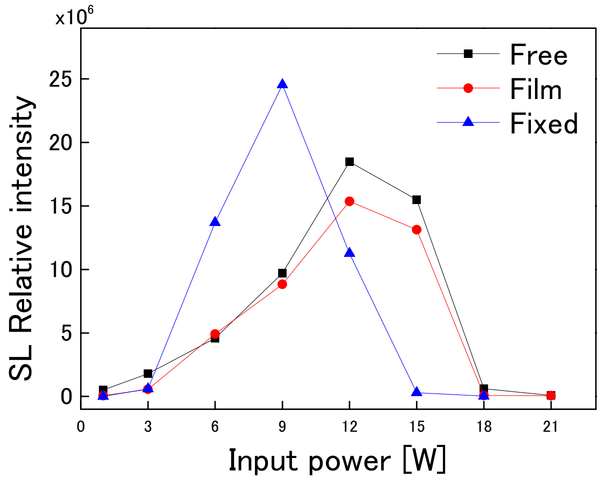

Fig.2 Power dependences of SL intensity for the three cases of boundaries.

Fig.2 shows the power dependence of the intensity of SL for the three cases of boundaries. We obtained the intensity by integrating the brightness of each pixel of photographs. SL intensity increased as power increases and showed a maximum at 12 W for the free end and at 9 W for the fixed end. Then intensity decreased and perfectly quenched at higher powers. The maximum is largest in the case of fixed end. The SL intensity is very similar for the two cases of free end.

Fig.3 shows high-speed images of acoustic bubbles. The characteristic of bubble dynamics at the power of 3 W (a) is bubble streaming with frequent coalescence. Streaming bubbles and bubble clusters exist simultaneously at 12 W (b). Only bubble clusters exist at 18W (c).

Fig.4 shows the power dependence of the acoustic emission spectra. Fundamental and continuous components increase linearly with the increase in acoustic power. Subharmonics, half of the driving frequency emerges at 3 W and increases rapidly more than other components. At 18 W, large hissing noise was suddenly noticed and subharmonics components drastically increased.

4. Conclusion

SL intensity increases with acoustic power since active bubble population increases. In this region only bubble streaming was observed. SL decreases when bubble clusters appeared. SL perfectly quenched at higher powers where only bubble clusters were observed. In this region, a large hissing noise and subharmonics components increased. This tendency was observed for the boundary of free end and also of fixed end.

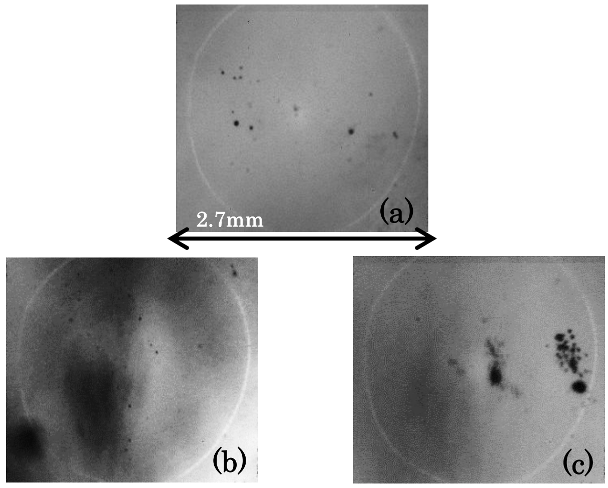

Fig.3 High-speed photographs of the acoustic bubbles for free-end boundary at (a) 3 W, (b) 12 W and 18 W at the speed of 64k fps.

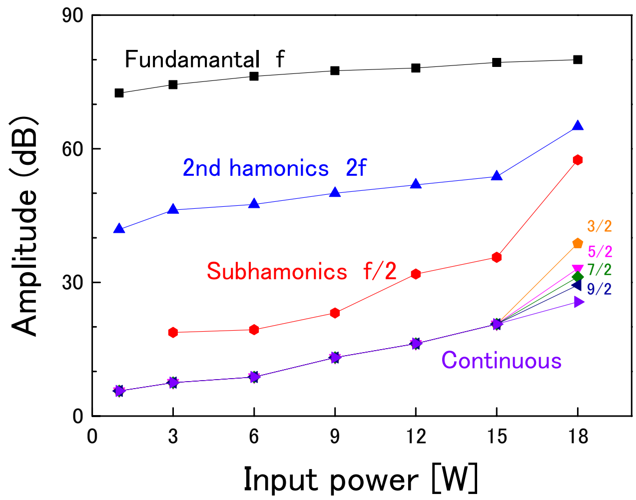

Fig.4 Power dependence of the frequency components in acoustic emission spectra.

Acknowledgment

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References

1. S. Hatanaka, K. Yasui, T. Tuziuti, T. Kozuka, and H. Mitome. Jpn. J. Appl. Phys. 40(2001)3856
2. D. Sunartio, M. Ashokkumar, and F. Grieser. J. Phys. Chem. B 109(2005)20044.