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Electric-fields effect on MBSL and SBSL intensities
MBSL と SBSL への電場の影響

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1. Introduction

Soluminescence (SL) is light emission from collapsing bubble generated in the liquid under intense ultrasound. Inside a collapsing bubble high-temperature and high-pressure conditions are established, and these conditions produce plasma. It is considered that the mechanism of SL is attributed to bremsstrahlung [1, 2].

We have observed an extraordinary light emission during multi-bubbles sonoluminescence (MBSL) measurements in He saturated water at 1 MHz [3]. The light was orange, and its spectrum showed He line around 700 nm. The ground electrode of the transducer, which was exposed to sample liquid, was damaged by cavitation erosion. The electric field leaked from the transducer affected sonoluminescing bubbles near the ground electrode. In this study, we have experimentally investigated the effect of electric fields externally controlled on MBSL and single-bubble sonoluminescence (SBSL) .

2. Experimental setup

For investigating MBSL, ultrasound frequency used was 300 kHz. We used He-saturated deionized water, which was contained in a rectangular cell made of acrylic plate (50 x 80 x 90 mm) equipped with quartz glass (ϕ 40). Biconvex lens was used for collecting light.

For SBSL, ultrasound frequency used was 28 kHz. We used degassed deionized water (DO=1.2 mg/L), which was contained a cylindrical cell (d= 64mm, h= 66mm) made of quartz glass. The temperature of the cell was kept at 15 ℃ by circulating temperature-controlled water. Zoom lens (x4) was used for observing the movement of the bubble. The electric conductivity of both solutions was 1 μS/cm.

Platinum needle (0.5mm diameter) was used as an hot electrode. The electrode was located 5 mm away from the ground electrode of the transducer. The electrode tip was faced to the ground. SL was captured with a digital camera (Canon EOS6D). The SL pulse was detected with photomultipliers (Hamamatsu Photonics, H7422-01) and was recorded with data logger (NF EZ5840). We applied direct-current (DC) voltage (± ~250 V) or alternating-current (AC) (250V) voltage which synchronizing with the ultrasound frequency.

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3. Results and discussion

3.1 Enhancement of MBSL

Figure 1 shows the variations of MBSL intensity. The upper figures represent the signal for 10 seconds. Only ultrasound was applied in (a), and ultrasound and +250 DC V were applied in (b). The lower images were captured at under ultrasound (a) and under ultrasound and +250 DC V (b).

The MBSL intensity increased by applying +250 V compared with that with no voltage was applied. Moreover intermittent increase in MBSL intensity was observed.

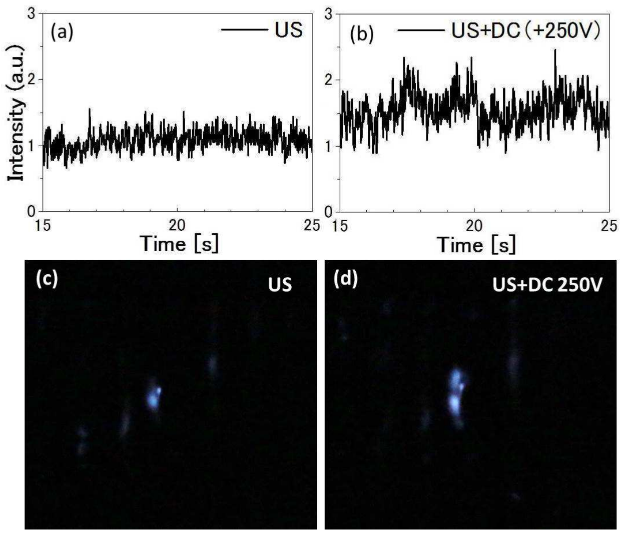

Fig.1 The upper figures are variations of MBSL intensity for 10 seconds only under ultrasound (a) and under both ultrasound and DC voltage (b). The lower images (c) and (d) were captured in a similar manner.

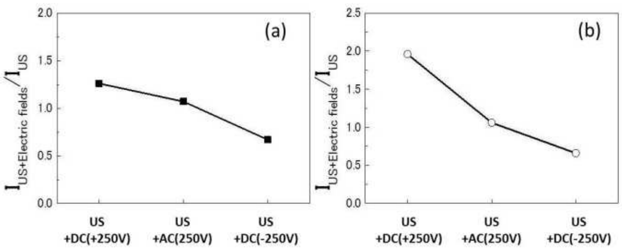

Fig.2 Increase rate of MBSL under an electric field obtained from SL pulses (a) and from the brightness of SL image (b)

Figure 2 shows the increase rate of MBSL intensity under an electric field. The values in Fig.2 (a) were calculated by averaging MBSL data for 180 seconds. The values in Fig.2 (b) were obtained by integrating the brightness of each pixel of photographs. Both results are in accordance.

MBSL was apparently changed when applying DC voltage. The increase rate of MBSL was largest at under +250 DC voltage. And MBSL decreased under -250 DC voltage. MBSL intensity exhibited a lesser change under AC voltage.

3.2 Effects to SBSL

Figure 3 shows the variations of SBSL intensity when DC voltage was applied. The applied voltage values were -20 V, and -30 V, -50 V, -90 V, -100 V, -115 V. The SBSL intensity decreased with increasing DC negative voltage. When positive voltage was applied, the variation of SBSL intensity showed the similar tendency to the case of negative voltage. A bubble can translate under electric fields.

Figure 4 shows the bubble position (a) and the distance of bubble movement (b) by applying various DC voltages. The bubble position and distance were measured from SBSL images. The distance of bubble movement increased as the applied voltage increases both for positive and negative voltage. The electrode and ground position was (7.3, 0.6), (-3.7, 0.93) in coordinates, respectively. Comparing Fig.4 with Fig.3, the SBSL intensity decreased when the distance of the bubble movement was larger. The bubble received attractive or repulsion force from the electrode when negative or positive voltage are applied, respectively. Therefore the bubble is considered to be positively charged.

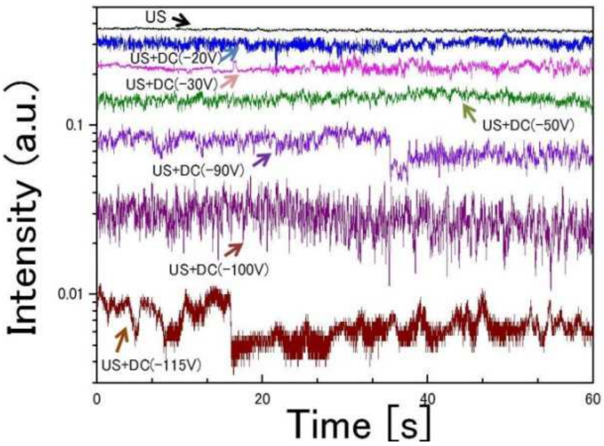

Fig.3 Dependence of SBSL intensity on electric voltage ranging from 0 to -115 V DC.

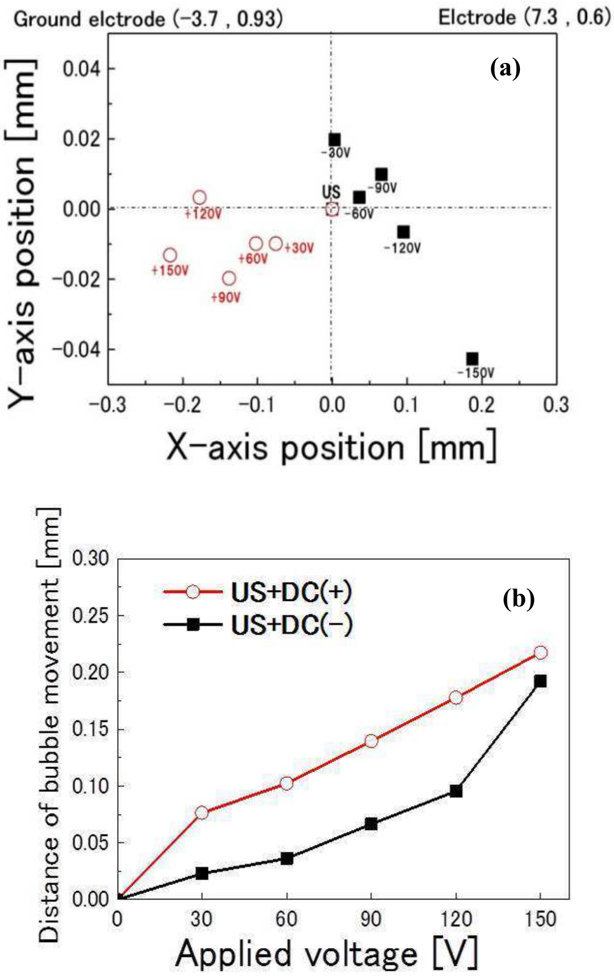

Fig.4 Translation of a SL bubble when various DC voltages were applied. The electrode and ground position was (7.3, 0.6), (-3.7, 0.93) in coordinates, respectively. Initial bubble position was at the origin. (a) coordinates representation, and (b) the distance of the bubble translation. Open circles represent the values under plus voltage and closed squares those under negative voltage.

4. Conclusion

Single sonoluminescing bubble is considered to be positively charged under DC voltage. The bubble position shift by receives attractive force or repulsion force from an electrode when under DC voltage. The decrease in SBSL intensity may due to the increase in non-spherical oscillation of bubble caused by bubble translation.

Multi bubbles generated in the solution repeat coalescence and disintegration consistently. This suggests bubble translation may not be an only factor affecting the increase in MBSL intensity. Some electric effect may participate in the SL process.

References

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