Bubble bursting

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Motivation

Bubbles exist everywhere in our daily life. For example, when we wash the dishes, small bubbles may be formed. They burst when their membrane become thin. Occasionally, we can see a ring of daughter bubbles occupy the initial rim of mother bubble. One research shows that daughter bubbles exist when Reynolds number is bigger than one. However, what condition can make a bubble form? What is the process of bubble bursting? Which factor makes the size of daughter bubbles change? In order to check them out, we will discuss the following topics**:** (1) Bond number (2) Falling velocity (3) Size of daughter bubbles.

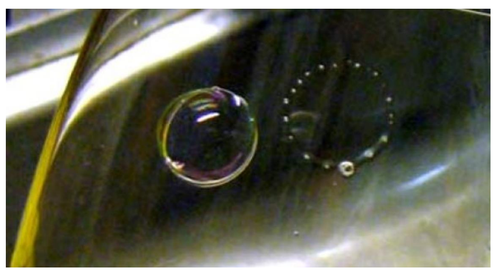


Figure 1 : A small bubble stick on the glass, and another bursting bubble is shown next to the small bubble. The bursting bubble remains a ring of small bubbles called daughter bubbles. The daughter bubbles enclose the contour of the mother bubble.

Analysis of surface tension

Bond number is one when the volume of bubble above water surface and that below water surface is equal. As a result, we pumped a bubble whose volume was divided equally by the water surface and measured its diameter. With the density of liquid, diameter and gravity acceleration, we got the surface tension by the following formula.

- $Bo = \frac{pgL^2}{\gamma}$ p: density of solution γ: surface tension g: acceleration of gravity L: characteristic length
- Solution**:** detergent
- Density**:** 1.0118(g/ml)
- Diameter: 4.48(mm)
- Surface tension**:** 199(mN/m)

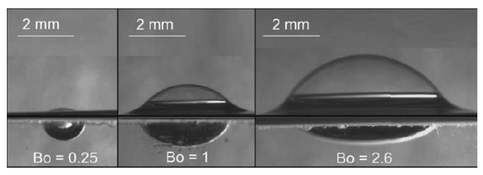


Figure 2 : Bubbles with different bond number. Citation from reference[1].

Bubble bursting process

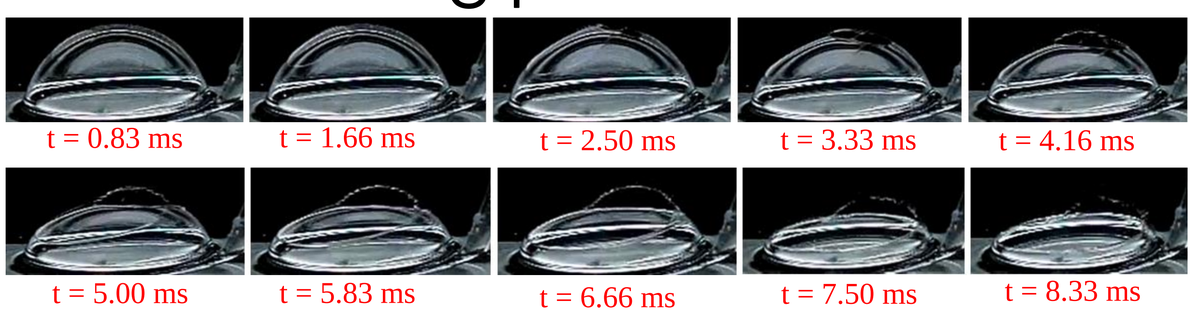


Figure 3 : High-speed camera whose frame rate is 1200 frames/second is used to catch the process of the bubble bursting. The images shows the process of bubble bursting in glycerol.

Thickness of bubble film

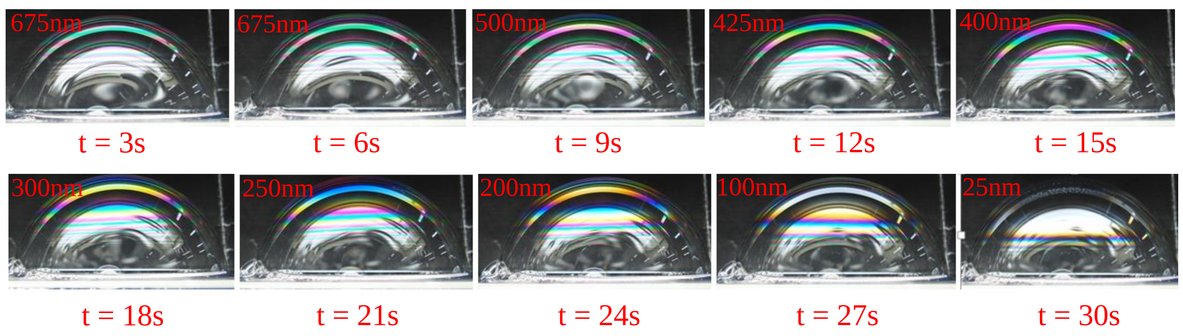


Figure 4 : The images show the thickness of bubble film in different time. By comparing the color on the apex of film and the reference chart below, the thickness of films can be known. However, there is no obvious difference between the thickness of the first and the second images since the low drainage velocity at first.

Falling velocity of bursting bubble

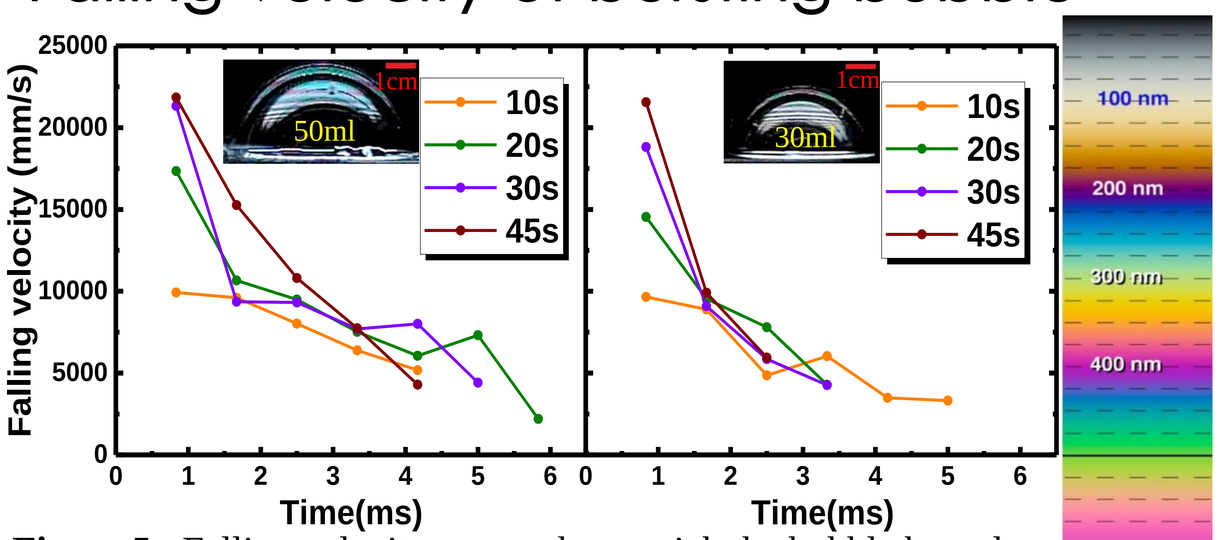
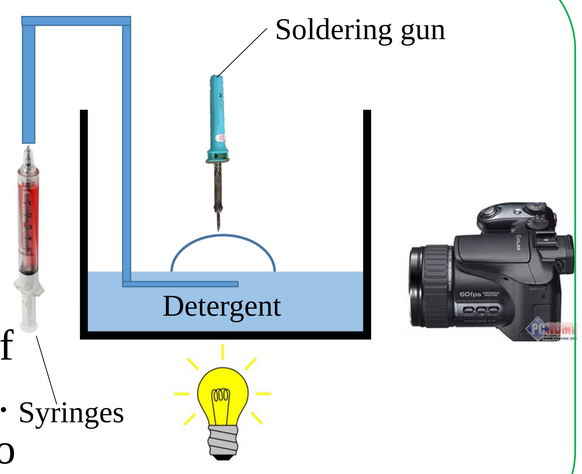


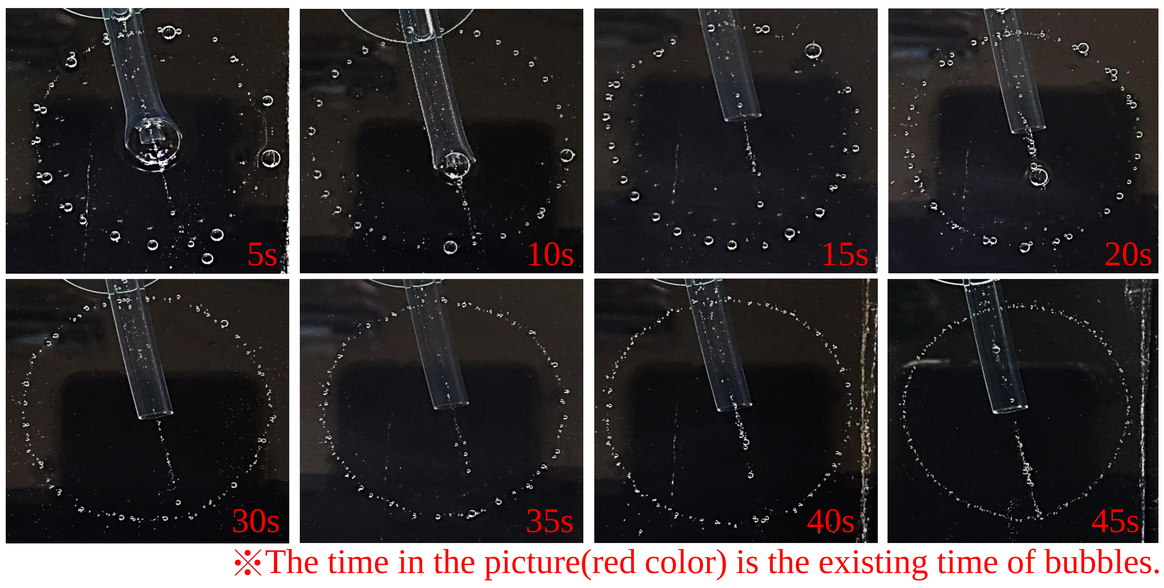
Figure 5 : Falling velocity means how quick the bubble boundary collapse in the process of bubble bursting. The bubble boundary falls down more quickly as the existing time of bubble is longer. The left and right diagrams show the falling velocity of bubbles with 50ml and 30ml respectively.

Setup

- Hot soldering gun is used to burst bubble.
- Using syringes to control the volume of air we pump in.
- Pictures taken from side view rather than top view owing to rough image of the reflection on the surface of bubble.
- Take picture from side view in order to analyze the falling velocity.



Daughter bubbles



※The time in the picture(red color) is the existing time of bubbles.

Figure 6 : The pictures show the daughter bubbles of bursting bubbles with different existing time. The daughter bubbles occupy the initial rim of bursting bubble on the surface of liquid. When the existing time of bubbles becomes longer, the average size of daughter bubbles becomes smaller and the total amount of daughter bubbles becomes more.

Average size of daughter bubbles

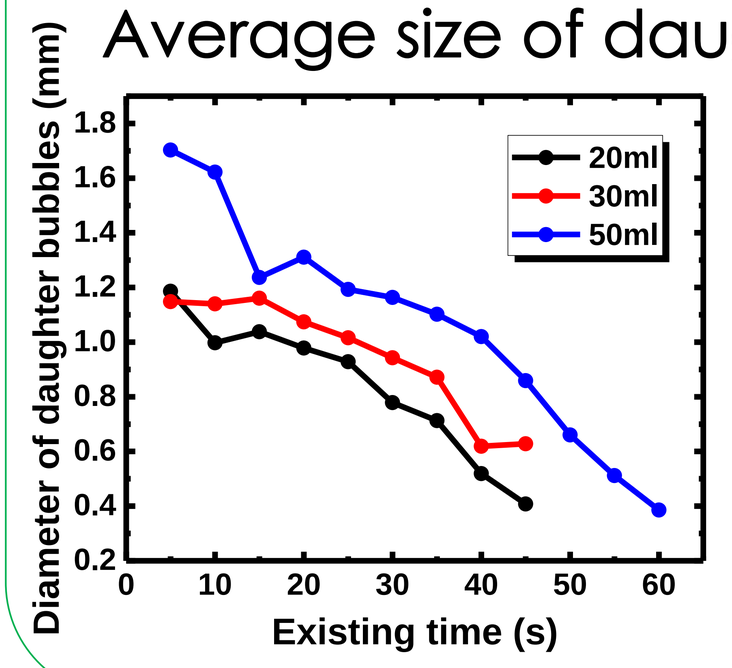


Figure 7 : This diagram shows that the average size of daughter bubbles is dependent on the existing time of mother bubbles. The longer the existing time of mother bubble is, the smaller the average size of daughter bubbles is. If the size of mother bubble with the same existing time become bigger , the average size of daughter bubbles will become bigger, too.

Conclusion

- Bond number is determined by surface tension force and buoyancy force. By measuring the buoyancy force of bubbles, surface tension can be confirmed.
- In the process of bubble bursting, the bubble boundary falls down quicker with thinner bubble film.
- As the existing time of bubbles increases, the size of daughter bubbles becomes smaller.

Reference

[1] Bird, J., de Ruiter, R., Courbin, L. and Stone, H. (2010). Daughter bubble cascades produced by folding of ruptured thin films. Nature, 465(7299), pp.759-762.

[2] Nguyen, C., Gonnermann, H., Chen, Y., Huber, C., Maiorano, A., Gouldstone, A. and Dufek, J. (2013). Film drainage and the lifetime of bubbles. Geochemistry, Geophysics, Geosystems, 14(9), pp.3616-3631.