Directional atomization with surface acoustic wave device for artificial pollination of strawberry

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1. Introduction

Strawberries are known to contain a large amount of nutritional value among fruits (**Fig. 1**)[1]. Therefore, stable supply of high-quality strawberries will lead to a solution of global food problems. Pollination is an important process in strawberry production. A standard method of pollination in strawberry cultivation is natural pollination by pollinating insects such as bees. Pollination methods using pollinating insects are easy on large fields. Meanwhile, stable production is difficult due to low temperatures, unseasonable weather, and insect conditions. One solution to this problem is artificial pollination using the cotton ball of an earpick[2]. Selective pollination is possible. However, manual pollination is inefficient. Recently, a method of pollination using soap bubbles has been reported[3]. While large scale pollination is possible, soap bubbles have low directivity because their movement is dependent on the wind. As a highly directional spraying method, an atomization method using surface acoustic wave (SAW) was focused on. However, it is concerned about the possibility of atomizing pollen with SAW devices because of their small atomizing particle size. Here, we demonstrate flight through atomization of lycopodium powders as a strawberry pollen model by fabricating a SAW device with a high output power.

2. Materials and Methods

2.1 Designs and Fabrications

SAW devices were fabricated using the lift-off method (**Fig. 2**). The wafers were 127.86° Y-X $LiNbO_3$ with a thickness of 0.5 mm. In order to print interdigital transducer (IDT) fingers for excitation of SAW with a resonance frequency of 30 MHz, aluminum was vacuum deposited on the wafer surface to form the IDT (**Fig. 3**). The resonance frequency of the fabricated SAW device was measured with an impedance analyzer (**Fig. 4**). In this study, aluminum was used as the IDT material. To achieve stable SAW excitation at high power, the IDT with an aluminum film thickness of more than 1 μm was fabricated. The film thickness distribution at the IDT fingers of the SAW device were measured (**Fig. 5**).

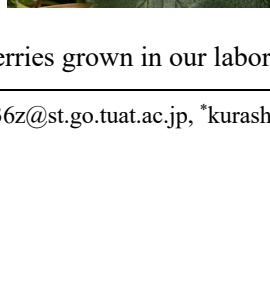

Fig.1 Strawberries grown in our laboratory.

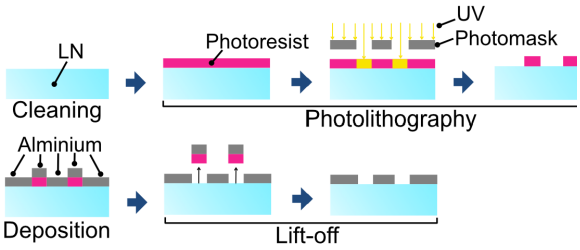

Fig.2 Lift-off method for fabrication of SAW devices.

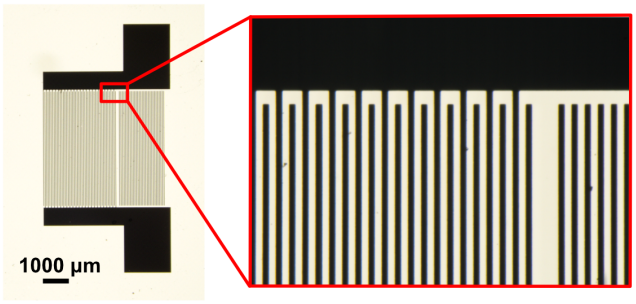

Fig.3 Fabricated SAW device.

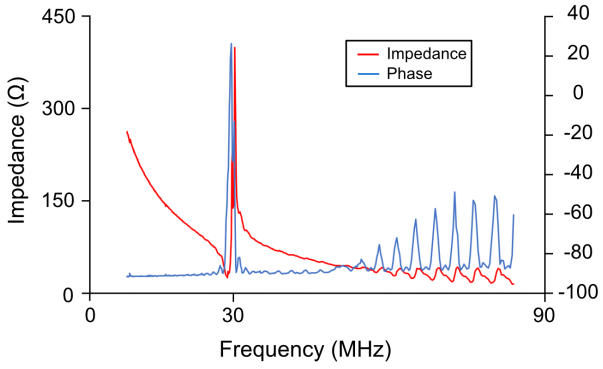

Fig.4 Impedance and phase measurements to obtain resonance frequency.

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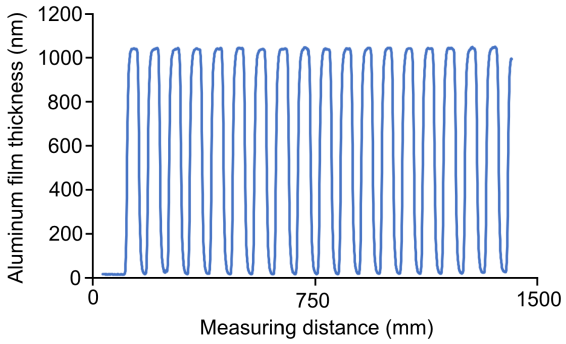

Fig.5 The film thickness distribution at the IDT fingers of the SAW device.

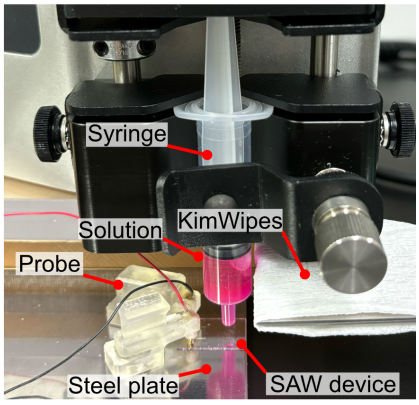

Fig.6 Experimental setup for atomization.

2.2 Atomization of a SAW device

Atomization experiments were conducted using the lycopodium powder stained with spores of *Lycopodium clavatum* in place of pollen. The lycopodium powder is mainly used as a pollen enhancer in artificial pollination. The particle size is 30~40 µm. Here, an AC voltage was applied to the SAW device. 0.06 mL of a solution of the lycopodium powder and water (1 w/v%) was atomized. The current value applied to the SAW device was kept constant at 1100 mA. The SAW device was excited at a resonance frequency of 30.1 MHz. This was obtained by impedance analyzer measurements. For atomization, the SAW device was mounted on the steel plate (**Fig. 6**). Steel plate was fixed at a height of 30 mm from the SAW device. The solution adhered to KimWipes wrapped around steel plates was observed under a stereomicroscope.

3. Results and Discussion

When an AC voltage was applied, the SAW device was observed to atomize directionally (**Fig. 7**). The solution on the KimWipes was observed under a stereomicroscope. The lycopodium powders in solution were also flown (**Fig. 8**). The number of the lycopodium powder contained in a 0.06 mL solution flown by the SAW device was compared to the number of the lycopodium powder contained in

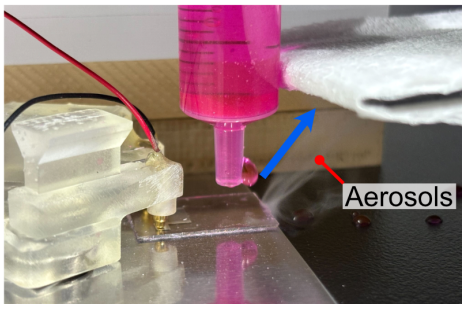

Fig.7 Observation of atomization in the SAW device when voltage was applied.

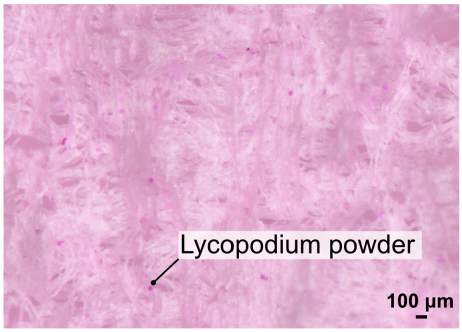

Fig.8 The lycopodium powders observed under a stereomicroscope.

a 0.06 mL solution dropped from a syringe. 80 lycopodium powders were dropped from the syringe, and 52 lycopodium powders were flown by the SAW device. Of the lycopodium powders dropped from the syringe, 65% flew by atomization.

4. Conclusion

To achieve stable strawberry pollination, we proposed the SAW device with directional atomization. We demonstrate flight through atomization of lycopodium powders as a strawberry pollen model by fabricating the SAW device with a high output power. As a result, the lycopodium powders were flown directionally by the SAW device. Our proposed pollen flight by atomization with SAW device has potential to achieve efficient and stable strawberry pollination.

Acknowledgment

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References

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