# Basic study of fine particle movement removal using microplasma actuator type electrodes

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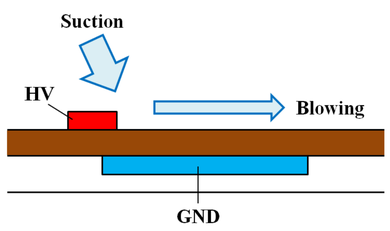
Fine particle control is gathering attention in the field of semiconductor manufacturing, indoor environment and so on. We have focused on the fine particle removal, and microplasma actuator type electrodes were utilized to remove fine particles by the electrostatic forces occurring on the electrode surface. We observed the fine particle movement and considered that the phenomenon of fine particle transfer is occurring on the surface.

## 1. Introduction

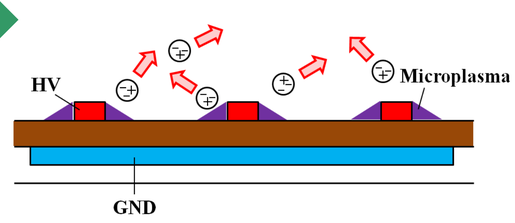
**Plasma actuator is expected as a new flow control device.**




**This device was applied to flow separation control, noise reduction, and so on.**

**However**

**The microplasma actuator type electrodes were not used for flow control but for fine particle removal.**

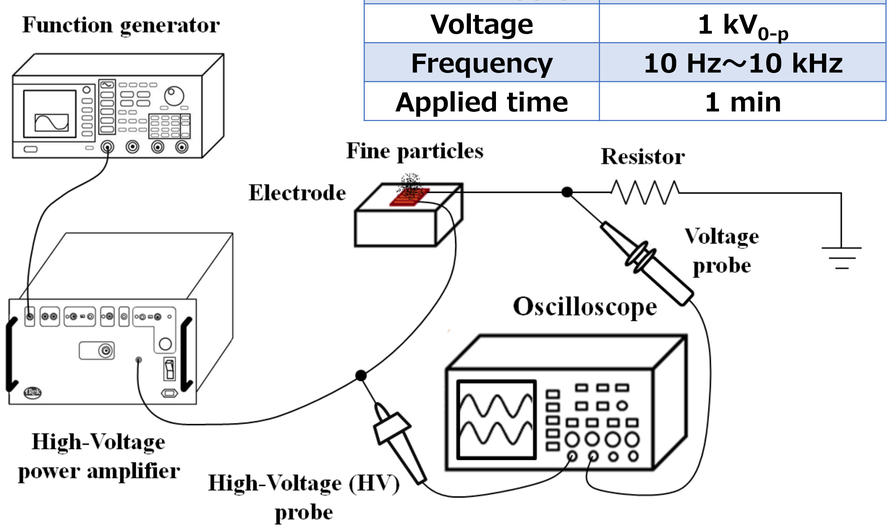



**Principle**

**① Fine particles are charged by the microplasma and by the contact with electrode.**
**② Charged particles were scattered due to the Coulomb and dielectrophoretic forces.**
**③ Fine particles were removed.**

## 2. Experimental setup

| Experimental conditions | |
|---|---|
| Power supply | AC |
| Voltage | 1 $kV_{0\text{-}p}$ |
| Frequency | 10 Hz～10 kHz |
| Applied time | 1 min |



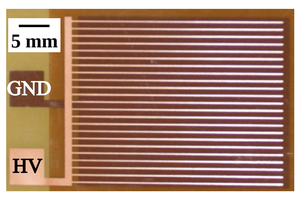

- **60 mg $SiO_2$ particles were placed on the electrode surface.**
- **Removal rate was defined by the following equation**

$$\text{Removal rate [\%]} = \frac{\text{The mass of particles moved to outside part}}{\text{The mass of particles placed on the electrode}} \times 100$$

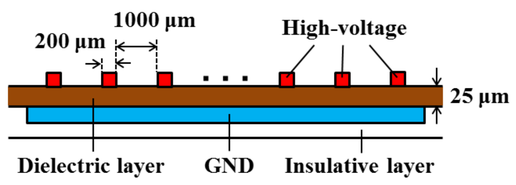
- **Particle movement was observed at each frequency.**

**Microplasma actuator type electrode**

**Top view**



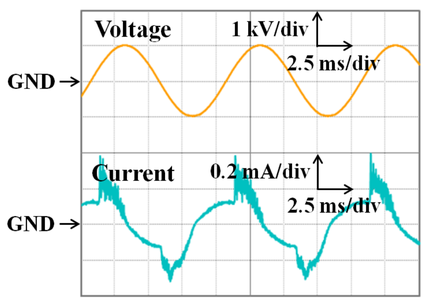

**Side view**



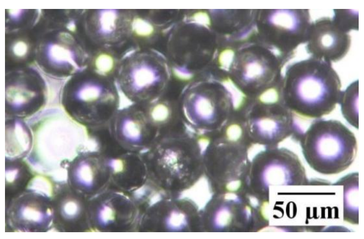

- **The thickness of the dielectric layer was set to 25 μm.**
- **Cupper electrodes was placed on both sides of dielectric.**
- **Upper and lower electrodes were connected to HV and GND, respectively.**

**Voltage & current waveform**

**(100 Hz)**



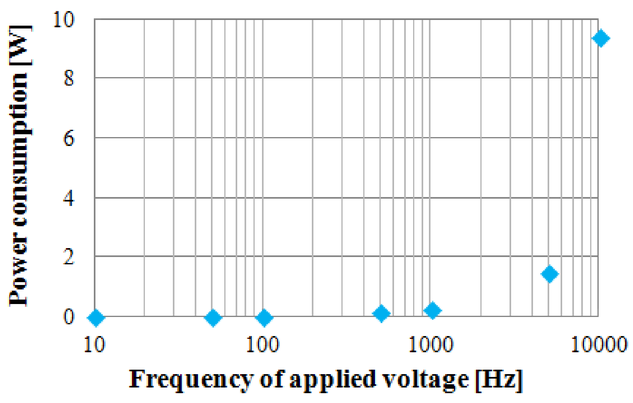

**Object particles**



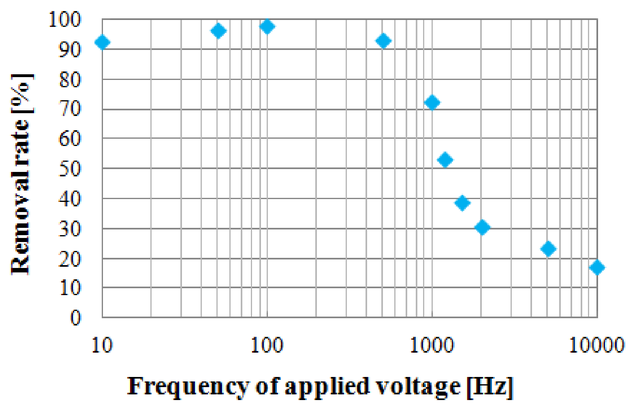

**$SiO_2$ particles**
**Diameter : 50 μm**
**Shape : spherical**

## 3. Results and Discussion

**Characteristic of power consumption**




**Characteristic of removal rate**

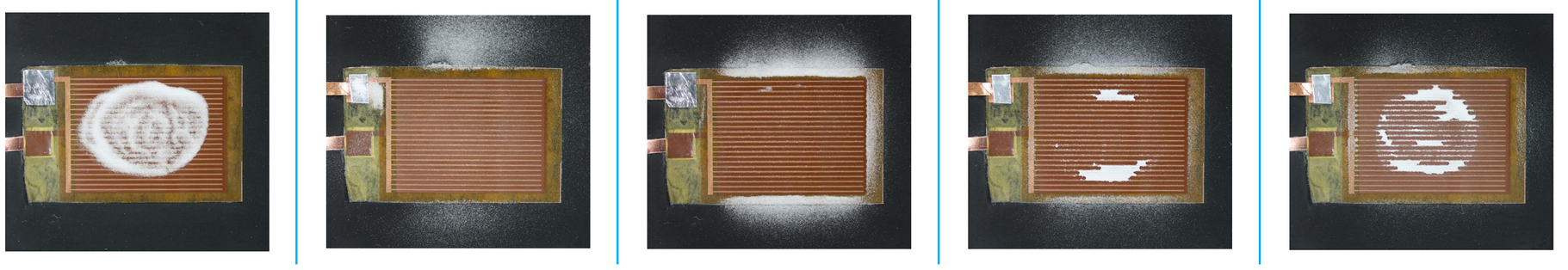



- **Power consumption increased proportionally to the frequency.**
- **Removal rate decreased as the frequency increased over 500 Hz.**
  **(At high frequency, the removal rate was low since the polarity of the voltage was inverted before charge amount of particles was enough to be removed.)**

**Removal efficiency was high at low frequency.**

**However, it took shorter time to remove particles as the frequency increased since many ions were generated at high frequency.**

| Before | 10 Hz | 100 Hz | 1 kHz | 10 kHz |
|---|---|---|---|---|



## 4. Conclusions

- Fine particle movement changed with the increase of the frequency of applied voltage.
- Removal rate of $SiO_2$ particles was about 95% between 10~500 Hz, while it decreased as the frequency increased over 500 Hz.
- At low frequency, it took longer time to move particles to the outside part of the electrodes since the number of generated ions was decreased as the frequency decreased.