Simulation of Electric Field Distribution on Meniscus of Electrospray with Zinc Oxide Material

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Abstract. Electrospray system had attracted attention of many researchers. It is due to easy to yield uniform thin film and possible for thin film mass production. The important parameters of electrospray process for getting uniform thin film are electric field distribution, surface substrate treatment and solvent properties. In this work, we observed electric field distribution on meniscus. Numerical work has carried out on this work. The material on meniscus used zinc oxide liquid properties. Voltage and walking distance between nozzle and substrate are the most important parameter to adjust electric field distribution. The decreasing walking distance with constant voltage yields increasing electric field distribution on meniscus. On vice versa, the increasing walking distance yields decreasing electric field distribution on meniscus. Increasing and decreasing voltage yields increasing and decreasing electric field distribution on meniscus, respectively.

Key words: electrospray, electric field, voltage, meniscus.

Introduction

Currently, energy issue is one of the main concern of the society. As the energy demand increases, sufficient energy source is required to meet these energy needs. One of the efforts to answer this issue is by diversification of energy sources whilst present supply is highly dependent on fossil sources. The use of renewable energy is an effort to bring diversification of energy into reality. One of the renewable energy that can be utilized is sunlight. Solar cell is a technology that could convert sunlight into electrical energy. At present, the development of solar cells technology is remarkably fast, starting with the first generation solar cells to fourth generation solar cells[1]. The performance characteristics of each generation can be summarized as follows: high cost and high efficiency (first generation, bulk silicon), low cost and low efficiency (second generation, thin film a-Si: H), low cost and high efficiency (third generation, organic photovoltaic), low cost and flexible (fourth generation, organic photovoltaic with plasmonic nano particles). Beyond the second generation of solar cells has started using thin films. Several methods are used today to make thin films such as chemical vapor deposition[2], atomic layer deposition[3], electron beam evaporators[4] and sputtering[5]. Most of the thin film making methods costs a lot in terms of equipment as well as the maintenance of the machines used. Some efforts to reduce the cost of solar cells by maintaining their good performance such as material choice and engineer the manufacturing and fabrication techniques. Electrohydrodynamic phenomenon has been attracted for new technique on microfabrication[6-8]. It can reduce production cost and possible for mass production. In this research, fabrication techniques are studied using electrospray based on electrohydrodynamic phenomenon method due to its relatively low cost and its high throughput that open the possibility for mass production processes[9]. Simulation was performed to find the optimal parameters that can be used at the next stage of the experiment to obtain a stable electrospray process.

Method

Data collection was carried out using numerical simulation. In this case, the software that was used is CST microwave studio. The results of this numerical simulation was obtained as an electrostatic phenomenon information in the form of electric field, which can then be used further for the determination of the area where the electrospray phenomenon was performed.

Result and Discussion

In current work, numerical simulation was carried out to determine the condition of the part that used as a voltage-producing component. Properties that resemble an ethanol-based solution of zinc oxide was used in this simulation.

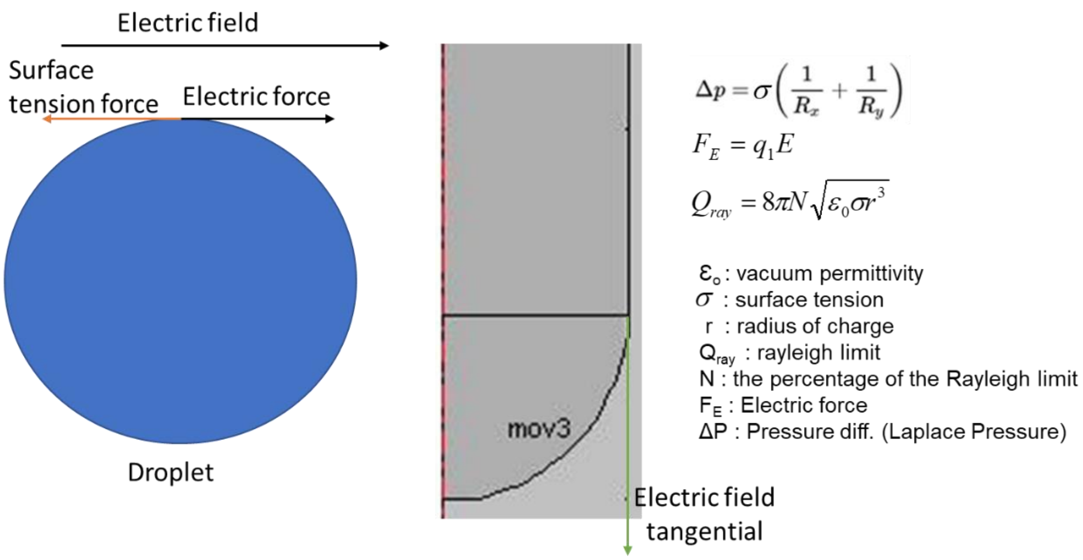

Figure 1 *Mathematical model used in the simulation*

Figure 1 provides a summary of mathematical model used in the simulation. Laplace pressure equation and electric force equation were used to investigate electrospray stable areas. The results of electric field distribution in tangential direction could be seen in Figure 2.

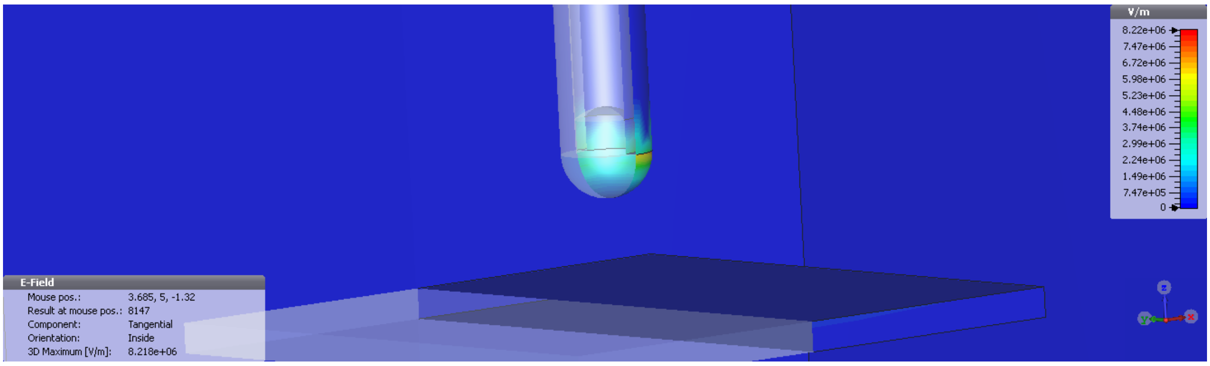

Figure 2 *Distribution of electric field in tangential direction along the surface of solution meniscus*

From this electric field distribution data, one could predict jetting stability area by taking N value between 0.1 - 0.25 which is the relative presentation value of coulomb fission had not yet occurred.

Surface force was estimated at 4.03 x 10^{-5} N. In this condition N = 0.1 as represented in Figure 3(a), for walking distance (WD) between 0.5-1 mm and voltage up to 2 KV still results in a stable jetting condition because the tangential direction of the electric force is still far below the surface tension force. From Figure 3(b) it could be seen that when the value of N = 0.15, system still exhibits a stable area for condition up to 2 KV voltage. At condition N = 0.2 (Figure 3(c)), it could be seen that the stable area was reached at the voltage around 1.6 KV for WD 0.5 mm and 0.75 mm. As for the WD 1 mm, the stable area was reached when the voltage was around 1.8 KV. Electric force for WD 0.5 and 0.75 mm did not show significant difference. Finally, in condition N = 0.25 (Figure 3(d)), stable area was begun to decrease. For the case of WD 0.5 mm - 0.75 mm the stable area was reached at 1.3 KV whilst for WD = 1 mm was reached up to a voltage of 1.4 KV.

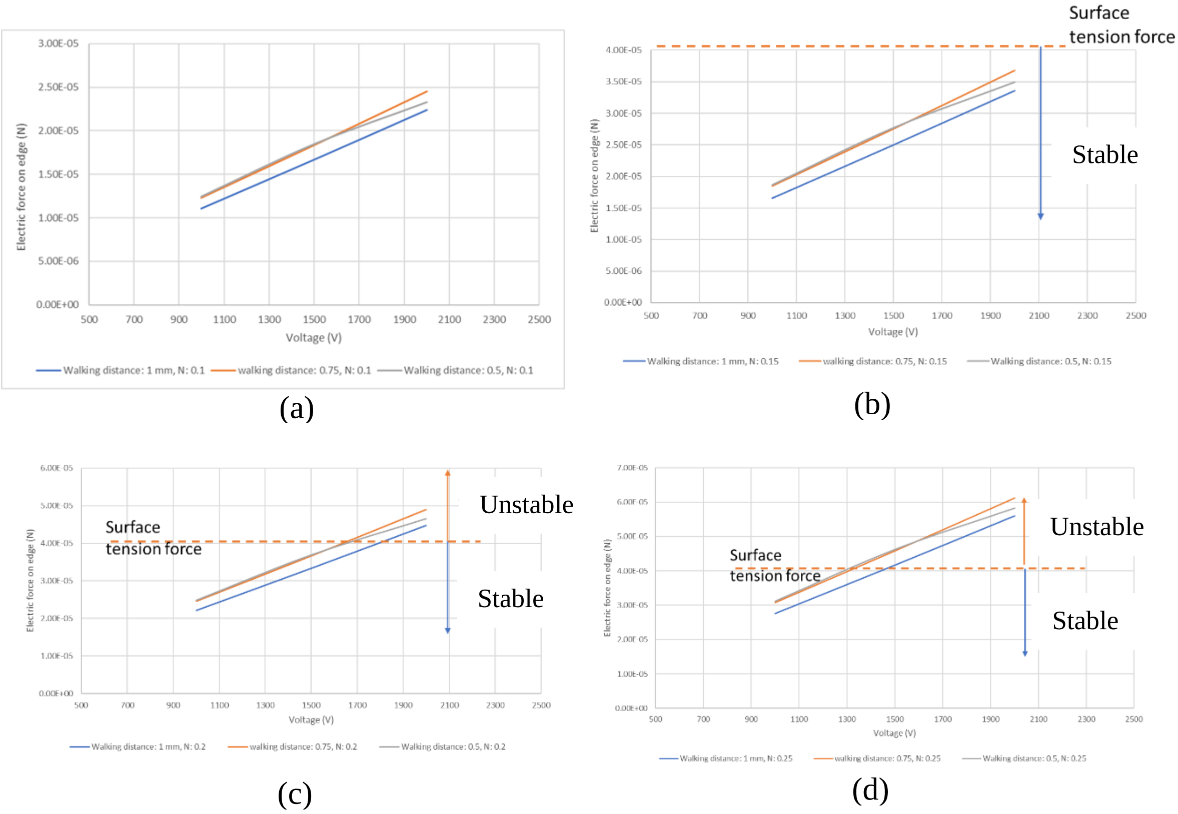

Figure 3 *Electric force on the tip of the nozzle at (a) N = 0.1, (b) N = 0.15, (c) N = 0.2, (d) N = 0.25.*

Conclusion

The stability of the jetting is determined by the property of the applied solution. Electric force at the end of the nozzle was carefully controlled since if the jetting occurs right at the tip of the nozzle, then the electrospray results become unstable. Based on the results of simulation, it was indicated that if the solvent used has an ethanol basis and the nozzle diameter is relatively small, the maximum operating voltage used was around 1.4 KV to maintain its stability. Moreover, walking distance (WD) that is safe to use for a 150 µm diameter nozzle is 1 mm. This was showed by the results of the electric force when WD is 0.75 mm and 0.5 mm, no significant electric force changes occurs.

Acknowledgement

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