17p-F5-13

# 転写モールド法アモルファスカーボンエミッタアレイの放電特性

## Discharge Characteristics of Transfer Mold Amorphous Carbon Field Emitter Arrays for Plasma Source Applications

静岡大院工，°文 宗鉉，中本 正幸

Graduate School of Eng., Shizuoka Univ., °Jonghyun Moon, Masayuki Nakamoto

E-mail: rjmoon@ipc.shizuoka.ac.jp

**[Introduction]** Conventional high pressure plasma sources such as dielectric barrier discharge have been proposed by using glow discharge operated by ac voltages with typical peak-to-peak amplitudes of 1.5-6 kV and frequencies of 1-200 kHz. However, the avalanche and the deformation of electrode occur due to the secondary ion bombardment by the high breakdown voltage. The low breakdown voltage and highly efficient discharge under high pressure would be expected by the enhancement of the local electric field concentration on cathode arrays having extremely uniform and sharp tips of Transfer Mold FEAs [1]. The purpose of this study is to realize the low breakdown voltage and highly efficient plasma source applications by using Transfer Mold field emitter arrays (FEAs).

**[Experiments]** Amorphous carbon FEAs (a-C FEAs) were fabricated by Transfer Mold method and were used as cathodes for plasma discharge. Transfer Mold a-C FEAs had the base lengths of 370−1570 nm. Discharge properties were evaluated by the ac voltage with the frequency of 2 kHz at the argon pressure of 2−6 kPa. Distance between the anode and cathode was 100 μm. Breakdown voltages were defined by the root mean square (rms) voltage at a current of 1 mA.

**[Results and Discussions]** Figure 1 shows SEM images of Transfer Mold a-C FEAs having base lengths of (a) 1570 nm and (b) 370 nm. The pitch of 1570 and 370 nm base lengths FEAs were 3140 nm and 740 nm, respectively. The average tip radii of 1570 nm and 370 nm base lengths FEAs were 7.8±1.5 nm and 3.8±1.3 nm. The decrease of emitter base length makes higher sharpness and uniformity of emitter tip. In addition, number of emitter tips for Transfer Mold FEAs having base lengths from 1570 to 370 nm, increase from $1.0\times10^{7}$ tips/cm$^2$ to $1.8\times10^{8}$ tips/cm$^2$, respectively. It means that local electric field concentration sites increase as the decrease of base length. Figure 2 shows relation between breakdown voltage and emitter base length of Transfer Mold a-C FEAs. Breakdown voltages at 2 kPa of 1570, 810, and 370 nm base lengths, were 201.3, 195.9 and 179.4 V, respectively. These values of Transfer Mold a-C FEAs, 179.4−201.3 V, are lower than those of other conventional dielectric barrier discharge having the approximated breakdown voltages of 530 V−2.1 kV. Moreover, breakdown voltages decreased from 201.3 V to 179.4 V as the decrease of base length from 1570 nm to 370 nm. Discharge efficiency would be enhanced by the increase of local electric field concentration because of the increase of emitter sites having higher sharpness and uniformity as the decrease of base length.

**[Conclusion]** Extremely sharp and uniform Transfer Mold a-C FEAs have low breakdown voltage of 179.4−201.3 at the pressure of 2 kPa, which are less than those of conventional dielectric barrier discharge. Transfer Mold a-C FEAs can be useful for the plasma applications having the low breakdown voltage and highly efficiency to a great extent.

[1] G. Sato and M. Nakamoto, Extended Abstract (the 54th Spring Meeting, 2007); The Japan Society of Applied Physics and Related Societies, 29p-G-8, p.164 (2007).

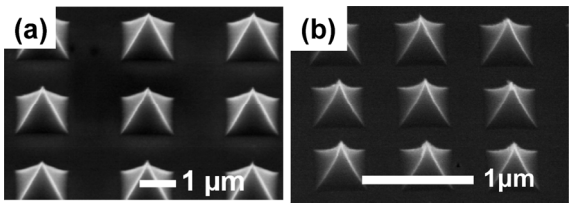


Figure 1. SEM images of Transfer Mold a-C FEAs having base lengths of (a) 1570 nm and (b) 370 nm.

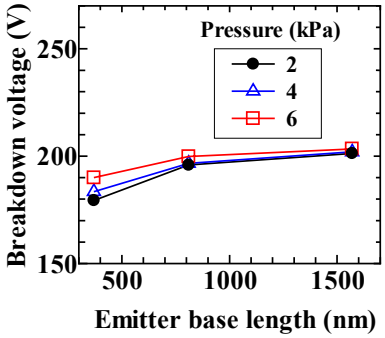


Figure 2. Relation between breakdown voltage and emitter base length of Transfer Mold a-C FEAs.