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転写モールド法極微小エミッタアレイの放電特性

Discharge Characteristics of Nanostructure Transfer Mold Field Emitter Arrays for Plasma Source Applications

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[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 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. The purpose of this study is to realize the low breakdown voltage plasma source applications by using nanostructure 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 110−1570 nm. Discharge properties were evaluated by the ac voltage with the frequency of 2 kHz at the argon pressure of 2 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 discharge I-V characteristics as a function of emitter base length for Transfer Mold a-C FEAs. Breakdown voltages of 1570, 810, 370, 190 and 110 nm base lengths, were 201.3, 195.9, 179.4, 173.7 and 166.0 V, respectively. These values of Transfer Mold a-C FEAs, 166.0−201.3 V, are lower than those of other conventional dielectric barrier discharge having the approximated breakdown voltages of 530 V−2.1 kV. Figure 2 shows relation between breakdown voltage and emitter base length of Transfer Mold a-C FEAs. Breakdown voltages decreased from 201.3 V to 166.0 V as the decrease of base length from 1570 nm to 110 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 110 nm, increase from 1.0×10^7 tips/cm^2 to 2.1×10^9 tips/cm^2, respectively. It means that local electric field concentration sites increase as the decrease of base length. Discharge breakdown voltage would be decreased 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 166.0−201.3 V, which are less than those of conventional dielectric barrier discharge. Nanostructure Transfer Mold a-C FEAs can be useful for the plasma applications having the low breakdown voltage to a great extent.

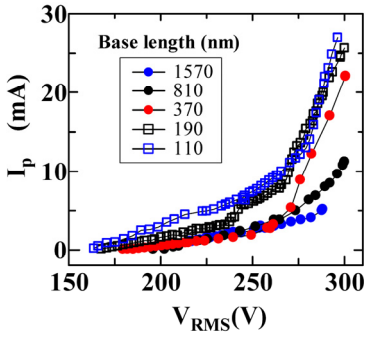

Figure 1. Discharge I-V Characteristics as a function of emitter base length for Transfer Mold a-C FEAs.

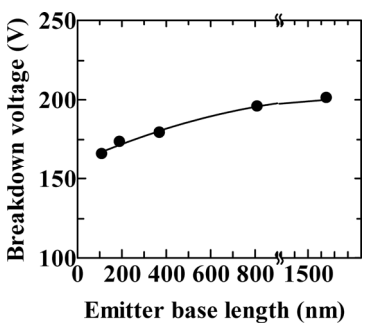

Figure 2. Relation between breakdown voltage and emitter base length of Transfer Mold a-C FEAs.