Diamond Vacuum Field Emission Devices

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Diamond field emitters have attracted considerable attention in vacuum microelectronics due to its low electron affinity for electron emission, hardness to withstand ion bombardment, and good thermal and electrical conductivity to handle high current. We have developed micro-patterned diamond pyramidal tips on diamond films by mold transferring technique[1] and achieved self-aligned gated diamond field emitter.[2] In this paper, we report the development of (a) vertical and (b) lateral diamond field emission devices with excellent field emission characteristics.

Vertically self-aligned gated diamond vacuum triode (Fig.1) was fabricated on a silicon-on-insulator (SOI) mold, which comprises a self-contained basic triode framework. This fabrication technique is practical and it utilizes the existing silicon micro patterning and etching techniques to define the anode, gate, and cathode early in the SOI mold fabrication stage prior to diamond deposition. The fabrication has achieved diamond field emitter triodes aver a large area. The field emission of the triode array exhibits transistor characteristics (Fig.2) with high dc voltage gain ~ 800 and good transconductance values. A high ac output voltage of ~100 V peak-peak has been achieved.

Lateral diamond vacuum diode (Fig.3) was fabricated on SOI wafer by a novel diamond patterning technique utilizing oxide patterning and lift-off process. An anode-cathode spacing of 2 μm between the diamond anode and cathode was achieved. The fabricated lateral diamond emitter diode exhibits excellent emission characteristics (Fig.4) with a low turn-on voltage of ~5 V and a high emission current of 6 μA, from a 4 diamond fingers configuration. The low turn-on voltage (turn-on field ~3 V/μm) and high emission characteristics are among the best of reported lateral field emitter structures.

Diamond field emission devices can be fabricated in vertical as well as lateral configurations. The fabrication techniques developed is practical and efficient. The field emission characteristics have potential applications in vacuum microelectronics, novel microsensors, and microelectromechanical systems (MEMS).

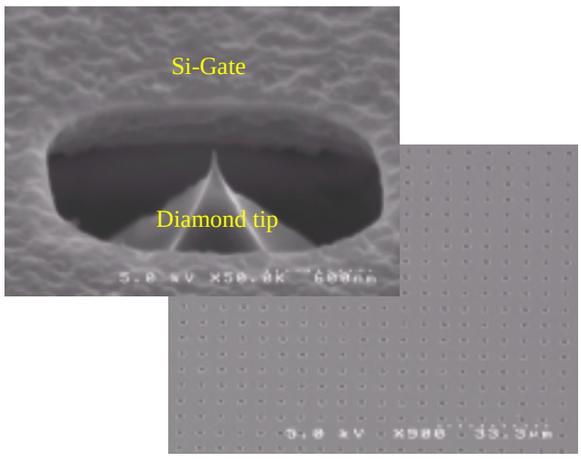

Fig.1: SEM of vertically self-aligned gated diamond vacuum triode

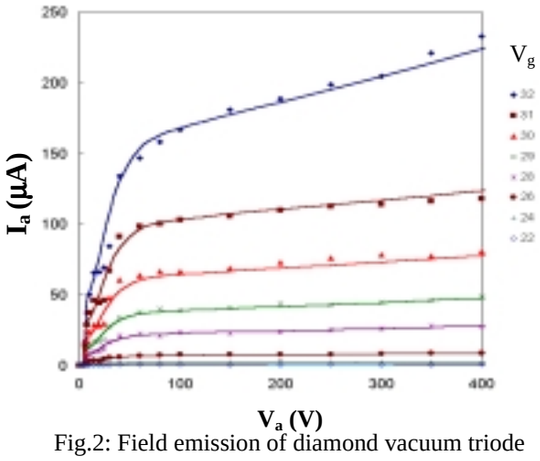

Fig.2: Field emission of diamond vacuum triode

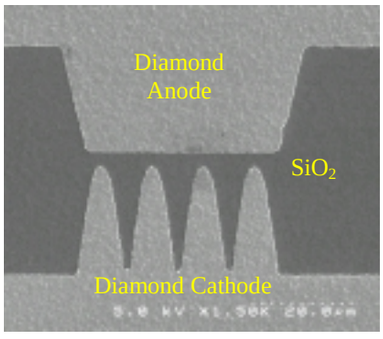

Fig.3: SEM of lateral diamond vacuum diode

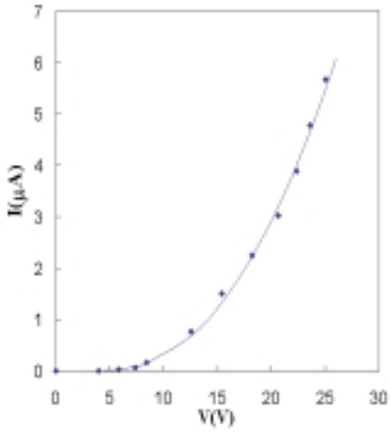

Fig.4: Field emission diamond vacuum diode

References:
[1] W. P. Kang, J. L. Davidson, and D. V. Kerns Jr., "Mold method for forming vacuum field emitters and methods for forming diamond emitters," *United States Patent Number: 6,132,278.*
[2] W. P. Kang, T. Fisher, and J. L. Davidson, "Diamond Microemitters – The New Frontier of Electron Field Emissions and Beyond," *New Diamond and Frontier Carbon Technology*, Vol. 11, No. 2, pp. 129-146, 2001.