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Investigation of field emission mechanism of undoped polycrystalline diamond films

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Carbon based materials have many attractive properties such as a wide band gap, a low electron affinity, and a high chemical and mechanical stability. Therefore, researches on the carbon-based materials as field emitters have been drawn extensively to enhance the field emission properties.[1-2] Especially, diamond gives high current density, high current stability, high thermal conductivity durable for high temperature operation, and low field emission behaviors. Among these properties understanding the origin of low field emission is a key factor for the application of diamond to a field emitter and the verification of the emission site and its distribution of diamond is helpful to clarify the origin of low field emission from diamond.

There have been many investigations[3-4] on the origin of low field emission behavior of diamond crystal or chemical vapor deposition (CVD) diamond films that is intentionally doped or not. However, the origin of the low field emission behavior and the consequent field emission mechanism is still not converged and those may be different between diamond crystal and CVD diamond films as well as the diamond that is doped or not. In addition, there have been no systematic studies on the dependence of nondiamond carbon on the spatial distribution of emission sites and its uniformity. Thus, clarifying a possible mechanism for the low field emission covering the diamond with various properties might be indeed a difficult work. On the other hand, it is believed that electron emission mechanisms of diamond are closely related to the emission sites and its distributions. In this context, it will be helpful to compare the spatial distribution of emission sites and field emission properties of the diamond films prepared by systematic variations of structural property.

In this study, we have focused on an understanding of the field emission mechanism for the CVD grown undoped polycrystalline diamond films with significantly different structural properties. The structural properties of the films were systematically modified by varying the CH_4/H_2 ratio and/or applying positive substrate bias voltage. The field emission properties and spatial distributions of the emission sites of the films have been examined. It was confirmed from the present study that the field emission characteristics are strongly dependent on the nondiamond carbon contents of the undoped polycrystalline diamond films, and a possible field emission mechanism for the undoped polycrystalline diamond films is suggested.

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