Surface conductive diamond: Homoepitaxial film growth for the control of carrier transport

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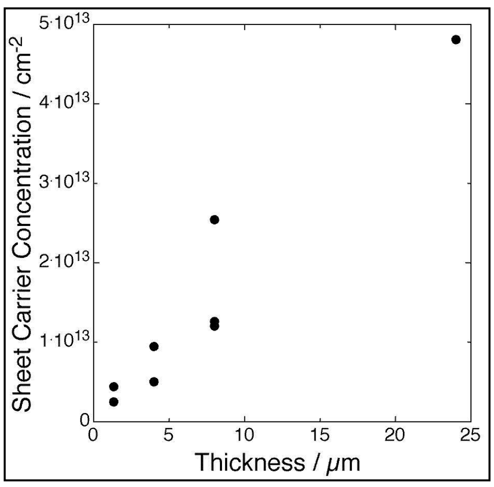
It is well established that a p-type surface can be generated on many forms of diamond following hydrogenation. This effect has been widely exploited to form some of the more promising diamond-based electronic device structures to be reported over the last few years. Whilst surface hydrogenation is required, it alone is insufficient for the formation of the p-type layer; metallic deposits and/or atmospheric adsorbates are additionally required. Whilst a lot of recent research effort has concentrated on elucidating the mechanism behind the formation of this p-type layer, less attention has been paid to how the density of carriers generated may be controlled. This is important if this technique for carrier generation is to make further progress in terms of advanced device designs, since the design Engineer will need to be able to locally control the carrier density that is present. Attempts to control the characteristics of the p-type layer by varying the nature of the hydrogenation process have proved mostly futile, with little evidence that, for example, longer hydrogenation periods yield higher carrier levels. Similarly, little control can be achieved by varying the type of diamond used, with single crystal and polycrystalline films revealing surprisingly similar carrier transport characteristics. In fact, only when there is a significant level of nitrogen within the diamond does the formation of a p-type layer not readily occur. It is from this position that the work to be presented in this paper takes its start. HPHT produced Ib single crystal diamonds do not support a p-type surface conductive layer following hydrogenation. However, following homoepitaxial growth, strong p-type characteristics can be measured on the 'as-grown' films.



We have carried out a systematic study of the carrier transport characteristics, as judged by Hall effect measurements, of as-grown homoepi layers grown on Ib diamonds. A clear correlation between overlayer thickness and carrier density has been demonstrated, enabling the device Engineer to 'tune' the characteristics of the device structure being made by the choice of overlayer thickness used. Moreover, we have found that surface roughness, both of the HPHT stone and the resultant overlayer, influence the nature of the p-type layer formed, and hence control over this parameter must also be excercised. In addition to Hall effect measurements, impedance and AFM/STM data will be presented. Homo-growth parameters will be revealed, for growth processes with rates as high as 50μm/hr.