Si 基板と接合した単結晶ダイヤモンドの残留応力評価

Residual stress evaluation of single crystal diamond bonded to Si substrate

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[Introduction] Diamond is the best potential candidate as the next generation semiconductor material for high power and high frequency electronic devices.[1] However, the cost of the diamond is several orders of magnitude more expensive than commercial available Si substrate. The combination of single crystal diamond and the large area wafer Si substrate would be useful for fabricating diamond-based power devices using Si LSI process facilities. We previously applied Surface Activated Bonding (SAB) method for fabricating Si/Diamond junctions and examined their structural characteristics.[2] Large residual stress should exist in the Si/Diamond heterostructure due to large lattice mismatch and the large difference of the surface energy between Si and diamond. In this work, we use Raman spectroscopy to characterize diamond substrate stress in the bonded Diamond/Si sample.

[Experiments] High-pressure high-temperature (HPHT) synthetic Ib type (100) single-crystal diamond and Si (100) substrates were bonded to each other at room temperature by SAB.[3] Raman spectroscopy measurements were performed using a Renishaw InVia system with a 488 nm Argon laser. The stress coefficient -0.567 cm^{-1}/GPa was used to determine the inbuilt stress in diamond substrate, referenced to a stress-free value of 1331.3 cm^{-1} measured for bulk diamond.

[Results] Figure 1 shows Raman spectra of bulk diamond and Diamond/Si junctions. The caracteristic Raman line for diamond is observed at 1331.3 cm^{-1} in the bulk diamond sample. The Raman line of Diamond/Si junctions is shifted to 1 cm^{-1} to lower wavenumbers, relative to that of the bulk diamond. This result indicats a tensile stress at the Diamond/Si bonded interface. The value of the tensile stress was determined to be 0.567 GPa considering a stress coefficient -0.567 cm^{-1}/GPa. This is the stress averaged over about 20-30 micrometer near the diamond-Si interface considering the confocal resolution of the microscope use.

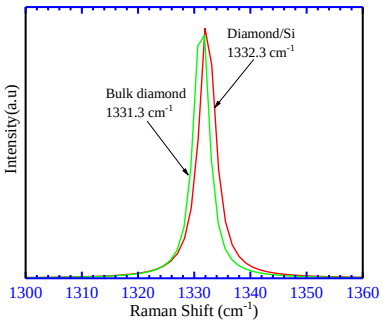

Fig. 1 Raman spectra of Diamond/Si junctions and bulk diamond.

[1] F. Nava, et al. Solid State Commun. 33, 475 (1980)

[2] J. Liang, et al. Appl. Phys. Lett. 110, 111603 (2017)

[3] J. Liang, et al. Electron. Lett. 49, 830 (2013).