Si-based quantum dots (QDs) have received intensive studied in the past decade because of their light emitting properties. Most Si-based QDs are fabricated to be embedded in silicon dioxide. Here we show that amorphous SiO$_x$ QDs can be embedded within single crystalline diamond. A SiO$_x$ film was deposited on a 2 mm (111) single crystal diamond substrate by sputtering. The sample was then treated with hydrogen plasma to form QDs, followed by microwave plasma chemical vapor deposition (CVD) of homoepitaxial diamond. Cross-sectional TEM specimens in diamond <110> orientation were prepared by focused ion beam. TEM/STEM observation was carried out in a JEOL ARM200F microscope with STEM annular dark field (ADF) image resolution of ~ 0.8 Å.

Figures 1(a) and (b) show typical STEM BF and ADF images, respectively, in which Si-based QDs are seen in dark and bright contrast. The size of the QDs is ~ 2-6 nm. The QDs covered with CVD diamond can be observed in the HRTEM image (Fig. 2). It can be seen that lattice fringes continuously cross over the areas of the QDs, illustrating diamond homoepitaxy. The atomically resolved STEM-ADF image in Fig. 3 shows a QD (~ 2 nm size) in very bright contrast superimposed with diamond atomic columns, indicating that the QD is amorphous and embedded in single crystalline diamond. Furthermore, only Si, O, and C peaks are detected in x-ray EDS measurements on those QDs, suggesting that the QDs are SiO$_x$ (x ~ 0.6). Also, photoluminescence measurements show light emitting wavelength at a peak > 520 nm.

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Fig. 1: (a) STEM-BF and (b) STEM-ADF images obtained from an interfacial region.

Fig. 2: HRTEM image showing diamond lattice fringes.

Fig. 3: STEM-ADF image in atomic resolution showing SiO$_x$ QDs in diamond.