Supplementary Materials

Electrical tailoring of the photoluminescence of silicon-vacancy centers in diamond/silicon heterojunctions

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Figure S1. The PL spectrum of the as-deposited diamond film excited by a 785 nm laser at liquid nitrogen temperature (77 K). A clear peak located at 948 nm indicates the presence of neutrally-charged SiV$^0$ centers. The inset shows the Raman spectra of the diamond film under the same excitation laser.
Figure S2. The SEM images of the diamond films annealed at various temperatures and durations: (a) 600°C-30 min; (b) 600 °C-60 min; (c) 700 °C-30 min.
Figure S3. XPS spectra of the C1 core carbon of the as-deposited samples before and after air annealing treatment: (a) the as-deposited sample; (b) the 600-30 sample; (c) the 600-60 sample; (d) the 700-30 sample. Due to the insulting nature of diamond, all the spectra are calibrated by aligning the sp³ C-C peak to the known literature value of 284.8 eV.
Figure S4. The PL spectra of the as-annealed sample before and after acid treatment.

In this process, the as-annealed (600-30) sample was soaked in mixed acid (H$_2$SO$_4$: HNO$_3$ = 3:1) at a temperature of 130°C for 120 min, in order to etch the surface sp$^2$-C introduced in the annealing process. The PL result clearly shows that the surface graphitization plays a negligible role on the PL intensity of SiV$^-$ centers in the whole depth.
Figure S5. The water contact angle of the as-deposited samples before and after air annealing treatment: (a) the as-deposited sample; (b) the 600-30 sample; (c) the 600-60 sample; (d) the 700-30 sample.
**Figure S6.** The PL signals collected at the region about 2 mm away from the electrodes with applying bias voltages on the diamond/n$^+$-Si heterojunction.

**Figure S7.** The PL spectra of the diamond/n$^+$-Si heterojunctions at different forward bias voltages.
Figure S8. UPS valence band spectrum of the as-deposited H-terminated diamond film, exhibiting the energy difference from vacuum level ($E_{VAC}$) to valence band maximum ($E_V$) is estimated to $21.2 \, eV - 15.9 \, eV = 5.3 \, eV$. The electron affinity of diamond ($\chi$) was derived by: $\chi = E_{VAC} - E_c = E_{VAC} - E_v - E_{dia} = 5.3 - 5.47 = -0.17 \, eV$. All energies are measured relative to the common Fermi level that is determined from a reference gold foil.