Supplementary Materials

Diamond photo-electric detectors with introducing silicon-vacancy color centers

Xiaokun Guo[1,2], Bing Yang[1,2,*], Xinglai Zhang[1,2], Jiaqi Lu[1,2], Ming Huang[1,3], Nan Huang[1,2], Lusheng Liu[1,2] and Xin Jiang[4,*]

[1] Shenyang National Laboratory for Materials Science (SYNL), Institute of Metal Research (IMR), Chinese Academy of Sciences (CAS), No. 72 Wenhua Road, Shenyang 110016, China;

[2] School of Materials Science and Engineering, University of Science and Technology of China, No. 72 Wenhua Road, Shenyang 110016, China;

[3]School of Environment and Chemical Engineering, Shenyang University of Technology, Shenliao West Road 111, Economic & Technological Development Zone 110870 Shenyang, China;

[4] Institute of Materials Engineering, University of Siegen, No. 9-11 Paul-Bonatz-Str., 57076 Siegen, Germany;

** Correspondence: byang@imr.ac.cn (B.Y.); xjiang@imr.ac.cn (X.J.)*

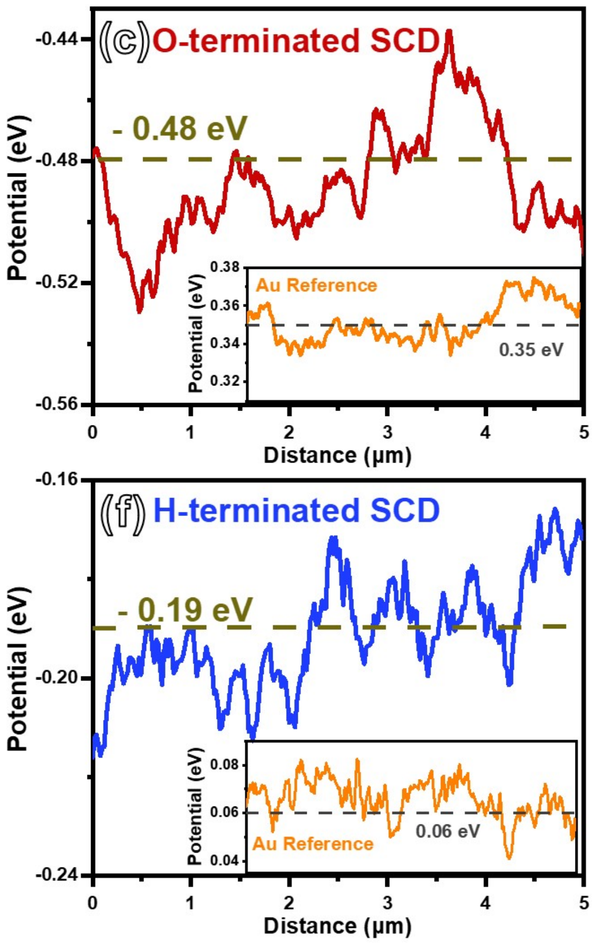

Fig. **S1** AFM images of the O-SCD (a) and the H-SCD (d). Corresponding KPFM surface potential maps of the O-SCD (b) and the H-SCD (e). Plots of the surface potential of the O-SCD (c) and the H-SCD (f) were measured along the white dash lines depicted in panels. The work functions of SCDs can be calculated by $\Phi_{SCD} = \Phi_{Au} + V_{SCD} - V_{Au}$, where Φ_{Au} is work function of gold reference (5.1 eV), V is contact potential difference (CPD) depicted in figure (c) and (f). The work functions of O-SCD ($\Phi_{O\text{-}SCD}$) and H-SCD ($\Phi_{H\text{-}SCD}$) are estimated to be 4.27 eV and 4.85 eV, respectively.

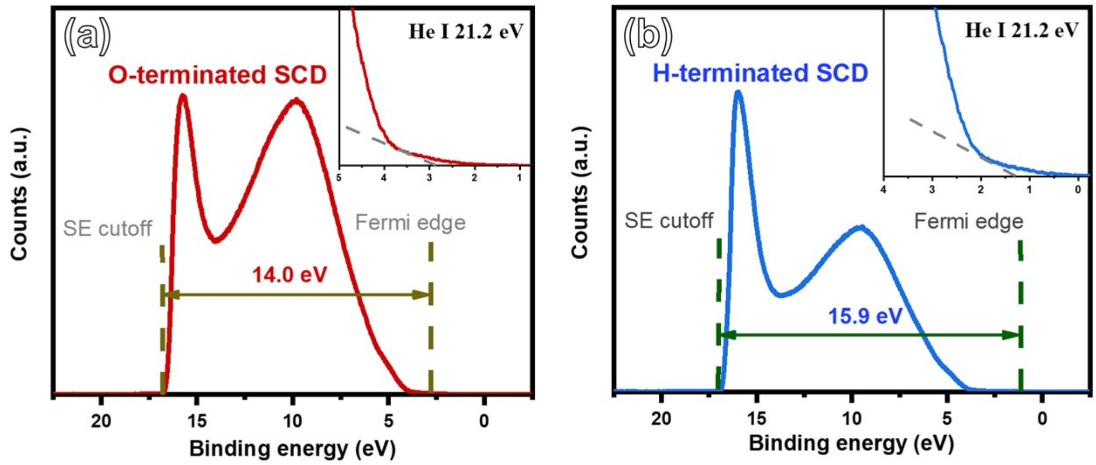

Fig. **S2** UPS spectra of the O-Dia (a) and the H-Dia (b) excited by He I photons ($h\nu$ = 21.2 eV). The emery difference between vacuum level (E_{VAC}) and valence band maximum (E_V) can be deduced by $E_{VAC} - E_V = h\upsilon - W$, here the W is electron band width that equals the distance between the second electron (SE) cutoff edge and Fermi edge.[1,2] Electron affinities (χ) can be further derived by: $\chi = E_{VAC} - E_C = E_{VAC} - E_V - E_g$, where the E_C is conduction band minimum and the E_g is band gap of diamond (5.47 eV). The $\chi_{O\text{-}Dia}$ and $\chi_{H\text{-}Dia}$ are estimated to be 1.73 eV and -0.17 eV, respectively.

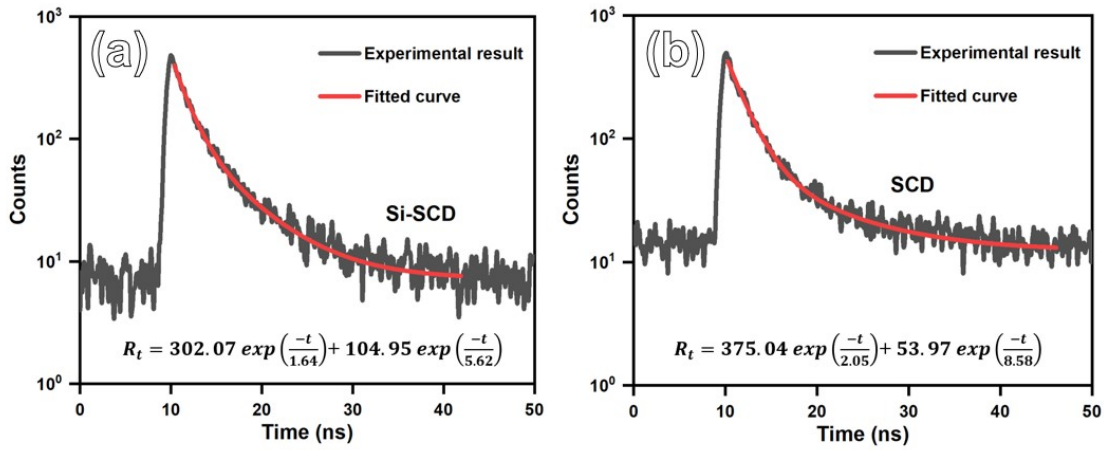

Fig. **S3** The TRPL spectra of the Si-SCD (a) and SCD samples. The fitting function of the bi-exponential decay is $R_t = A_1 exp(-t/\tau_1) + A_2 exp(-t/\tau_2)$. The average lifetime can be calculated using $\tau_{ave} = \left(A_1{\tau_1}^2 + A_2{\tau_2}^2\right)/(A_1\tau_1 + A_2\tau_2)$. The result show that the τ_{ave} of the Si-SCD and SCD is 3.80 ns and 4.50 ns, respectively, indicating a shorter lifetime of photoinduced carriers in Si doped sample. Hence, the defect density in Si-SCD should be higher than the SCD sample, which also act as trapping center and lead to a longer response time of photo-electrical signals.

Tab. **S1** Power densities of light sources with different wavelengths measured using a photometer with a window area of 1 cm^2.

Wavelength (nm)	220	254	365	400	450	532	650
Power (mW/cm^2)	0.330	0.087	0.134	0.238	0.307	0.250	0.157

Tab. **S2** Photocurrents and responsivities of the Si-SCD and the SCD devices under illuminations of different wavelengths (15V bias)

Wavelength (nm)		220	254	365	400	450	532	650
	I_{Ph} (A)	3.58×10^{-8}	2.37×10^{-10}	1.24×10^{-10}	1.84×10^{-10}	7.03×10^{-11}	3.72×10^{-11}	2.68×10^{-11}
Si-SCD	I_{net} (A)	3.58×10^{-8}	2.31×10^{-10}	1.18×10^{-10}	1.84×10^{-10}	6.46×10^{-11}	3.15×10^{-11}	2.11×10^{-11}
	R (A/W)	3.62×10^{-2}	8.85×10^{-4}	2.94×10^{-4}	2.57×10^{-4}	7.01×10^{-5}	4.96×10^{-5}	4.47×10^{-5}
	I_{Ph} (A)	4.63×10^{-8}	2.83×10^{-12}	2.49×10^{-12}	1.86×10^{-12}	1.77×10^{-12}	1.72×10^{-12}	1.74×10^{-12}
SCD	I_{net} (A)	4.63×10^{-8}	0.71×10^{-12}	0.89×10^{-12}	0.24×10^{-12}	0.17×10^{-12}	0.12×10^{-12}	0.14×10^{-12}
	R (A/W)	4.68×10^{-2}	2.72×10^{-6}	2.21×10^{-6}	5.97×10^{-7}	1.85×10^{-7}	1.60×10^{-7}	2.97×10^{-7}

References

[1] Liu Z Q, Chim W K, Chiam S Y, et al. An interface dipole predictive model for high-k dielectric/semiconductor heterostructures using the concept of the dipole neutrality point. Journal of Materials Chemistry, 2012, 22(34): 17887-17892.

[2] Diederich L, Küttel O M, Aebi P, et al. Electron affinity and work function of differently oriented and doped diamond surfaces determined by photoelectron spectroscopy. Surface science, 1998, 418(1): 219-239..