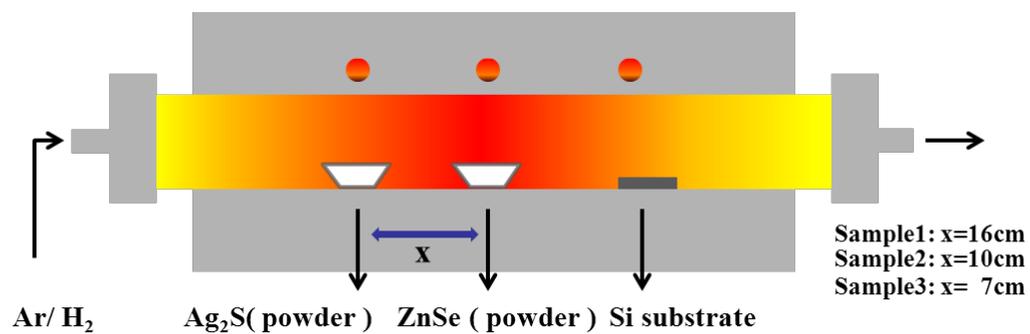
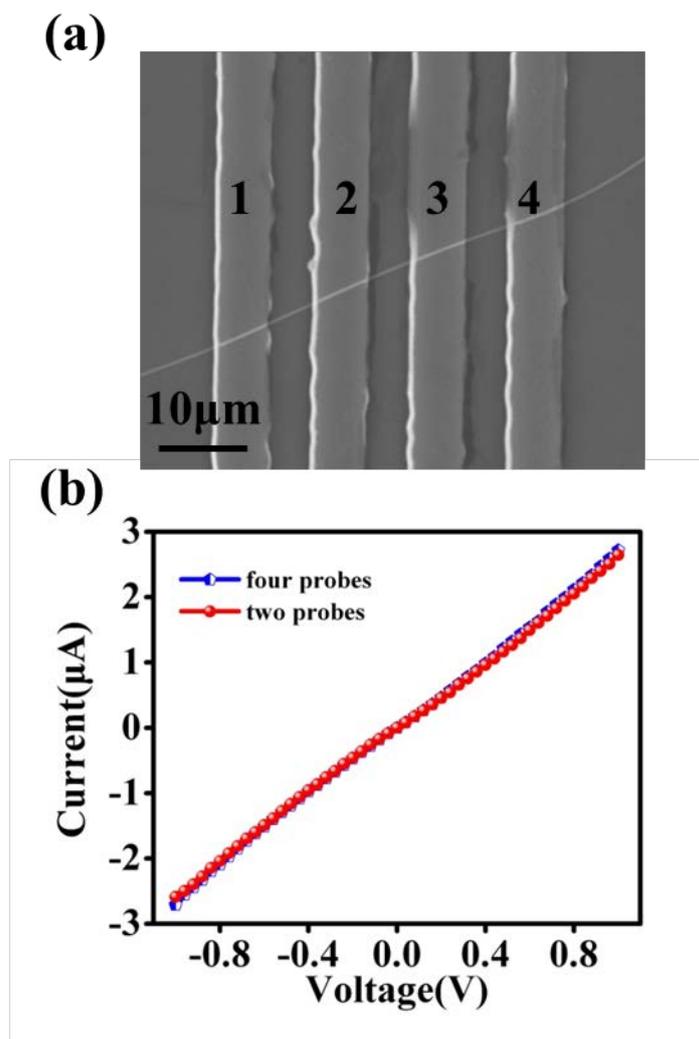


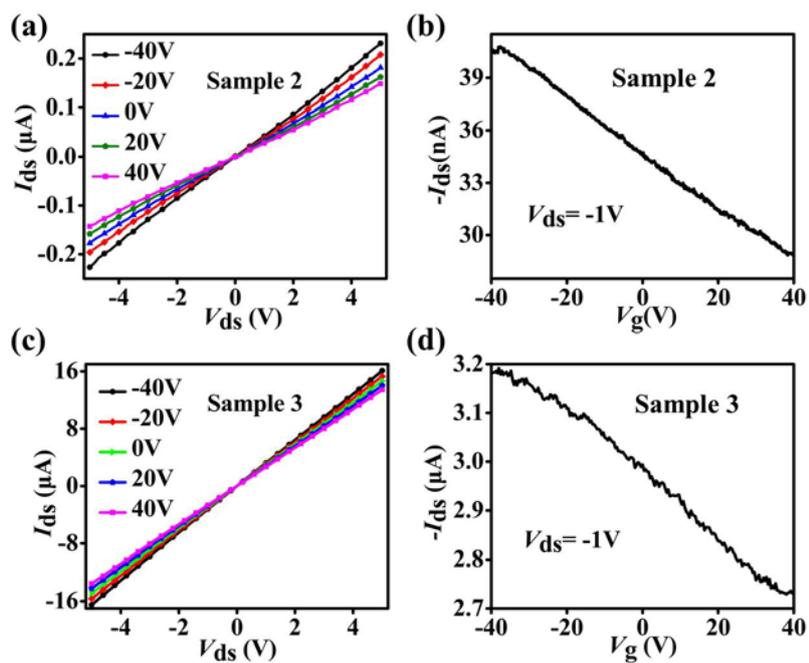
## Supporting Information



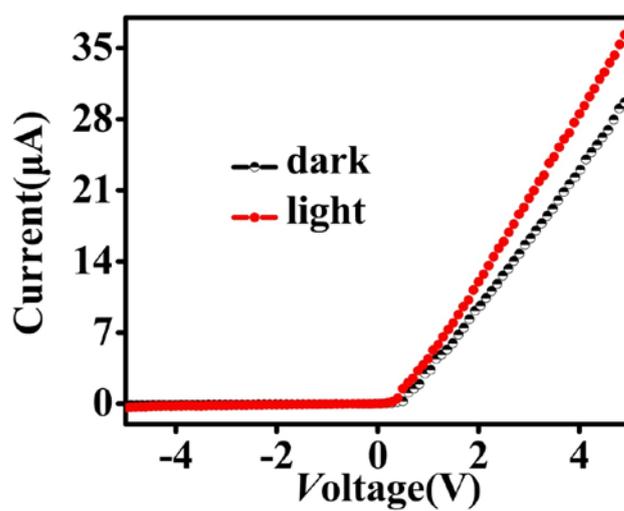
**Fig. S1** Schematic illustration shows the experimental setup for the synthesis of Ag-doped ZnSe NWs with different doping levels.



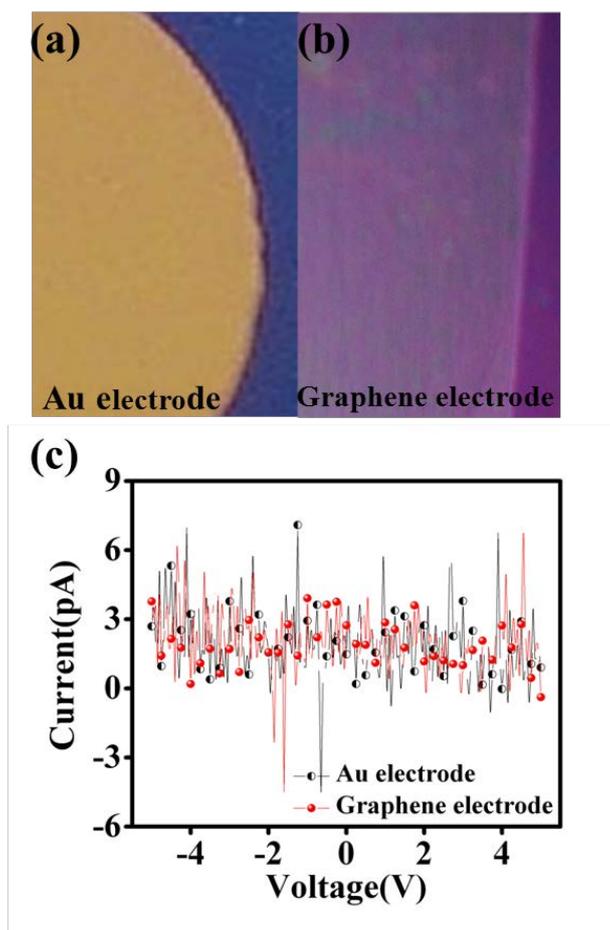
**Fig. S2** (a) SEM image of the device fabricated on a single ZnSe:Ag NW (Sample3) for four-probe detection. (b) *I-V* curves of a single ZnSe:Ag NW measured by two-probe and four-probe methods, respectively, with Cu/Au electrodes.



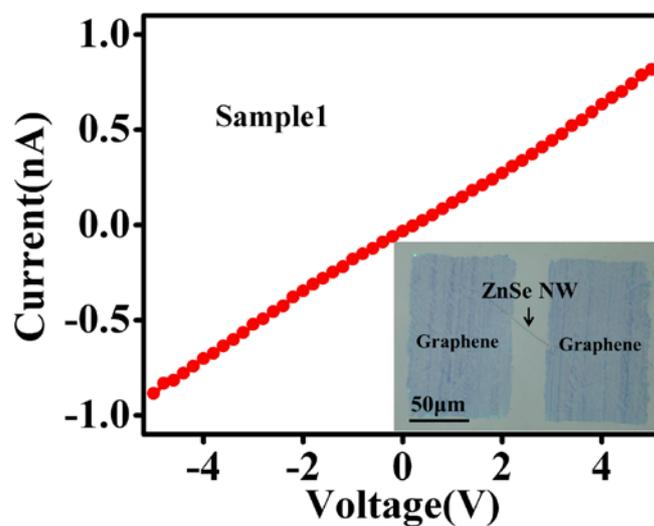
**Fig. S3** Electron transfer characteristics of the NWs from Sample 2 and 3. (a) and (c)  $I_{ds}$ - $V_{ds}$  curves measured under different  $V_g$  ranging from +40 to -40V with a step of -20 V. (b) and (d)  $I_{ds}$ - $V_g$  curves measured at fixed  $V_{ds}=-1$  V.



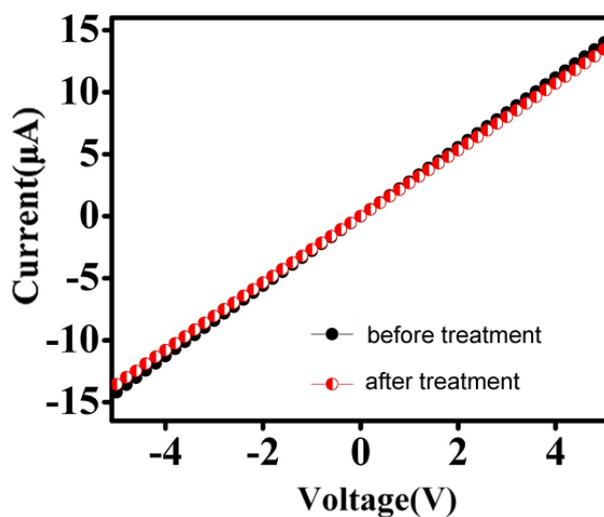
**Fig. S4** *I-V* curves of the nanoSBD measured in dark and in light (white light (0.35 mWcm<sup>-2</sup>), respectively).



**Fig. S5** Optical images of the devices without the use of ZnSe:Ag NW arrays. PMMA layers in the devices were spin-coated and plasma treated under the same conditions with that in ZnSe NW array/Si p-n heterojunction devices. (a) Device with Au electrode. (b) Device with graphene film electrode. (c) *I-V* curves of the devices measured with Au and graphene film electrodes, respectively. Only noise signals could be detected in the case of no p-ZnSe NW arrays were used, indicating that the photovoltaic behaviors observed in this work came from the ZnSe NW array/Si p-n heterojunctions but not the leakage current between the electrodes and the Si substrate.



**Fig. S6** Typical *I-V* characteristics of a single ZnSe:Ag NW measured with graphene film electrodes, revealing the good ohmic contact of graphene with the p-ZnSe NW. Inset shows the optical image of the device. It is noted that the PMMA layer on the graphene film was not removed to ensure that the graphene film could be viewed in the optical microscopy.



**Fig. S7** *I-V* curves of a p-ZnSe NW (Sample 3) measured before and after treatment in oxygen plasma (10.5 W) for 2 min. The device shows little change in the conduction current after plasma treatment, therefore the influence of plasma treatment on the photovoltaic characteristics of the ZnSe NW array/Si heterojunctions could be excluded.