Supporting Information

Wafer-scale metal chalcogenide thin films via ion exchange approach

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Further results

Table 1S. synthetic conditions for ion exchange reactions and percentage of chemical composition of three metal chalcogenide thin flims after ion exchange reactions.

Thin films	Reactants	Temp.(°C)	Time	Cd%	Cu%
CdS	Ag_2S 5mmol$Cd(NO_3)_2$ 0.25mlTBP 50ml methanol	50	5h	96.66	

CdSe	Ag_2Se 5mmol $Cd(NO_3)_2$ 0.25ml TBP 50ml methanol	50	5h	99.34	
Cu_2S	CdS 48mg$[MeCN]_4$CuI PF_6 10ml methanol	30	10min		98.46
Cu_2Se	CdSe 48mg$[MeCN]_4$CuI PF_6 10ml methanol	30	10min		97.85

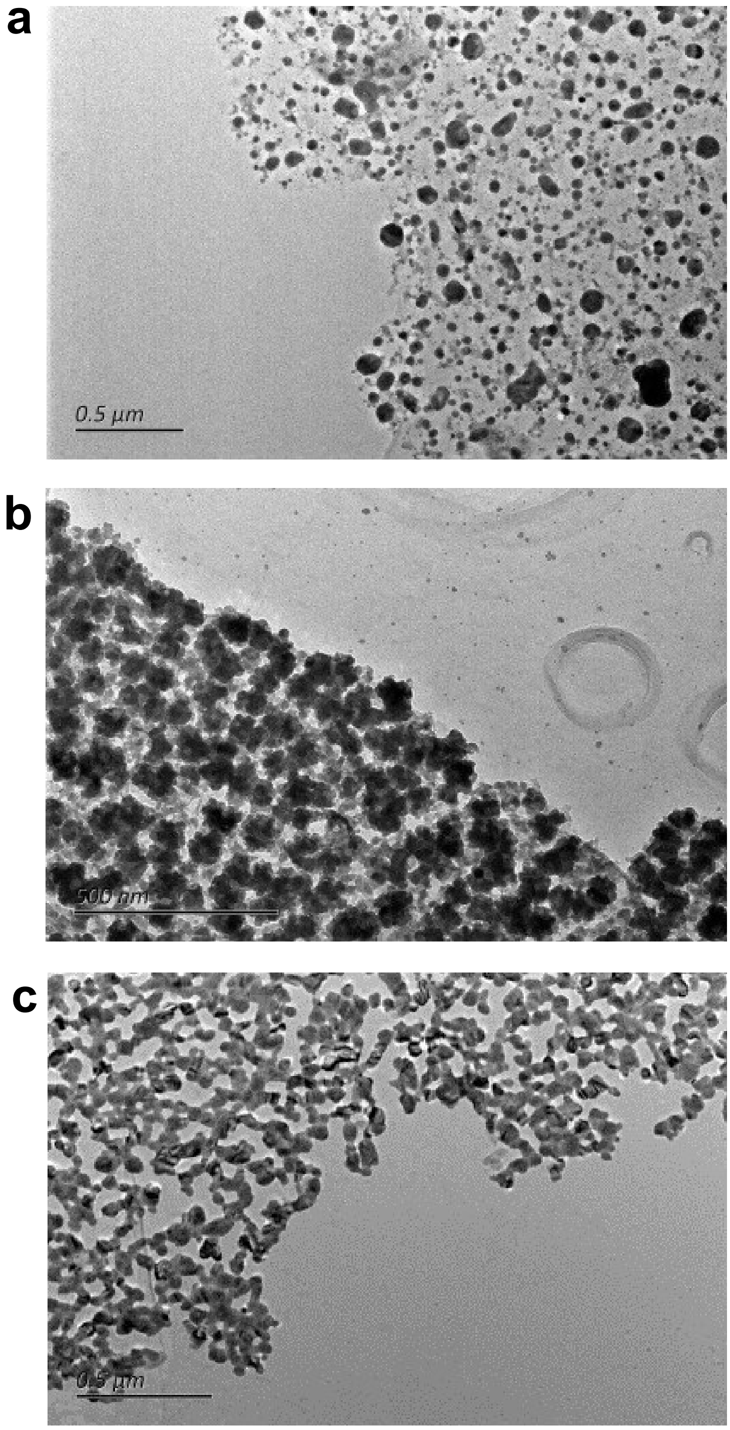

Figure 1S (a) the Ag_2S thin film on SiO_2/Si obtained in the furnace at 200℃ for 2h. (b) the Ag_2S thin film on sapphire obtained in the furnace at 200℃ for 2h. (c) the Ag_2S thin film on SiO_2/Si obtained at room temperature with H_2S as the sulfur source.

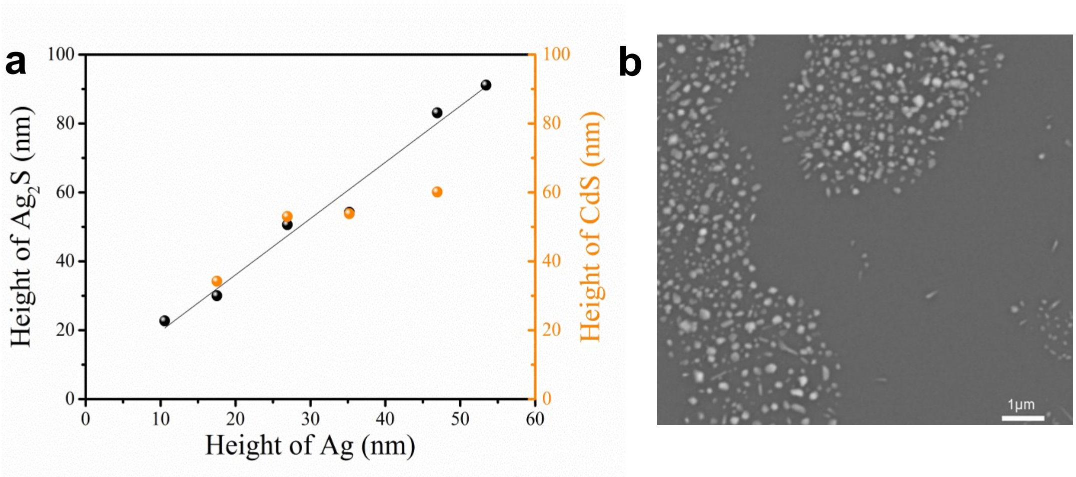

Figure 2S (a)the plot about the relation among Ag thin films, as-prepared Ag_2S and CdS. (b) SEM image of CdS when the thickness of silver thin film is less than 10nm

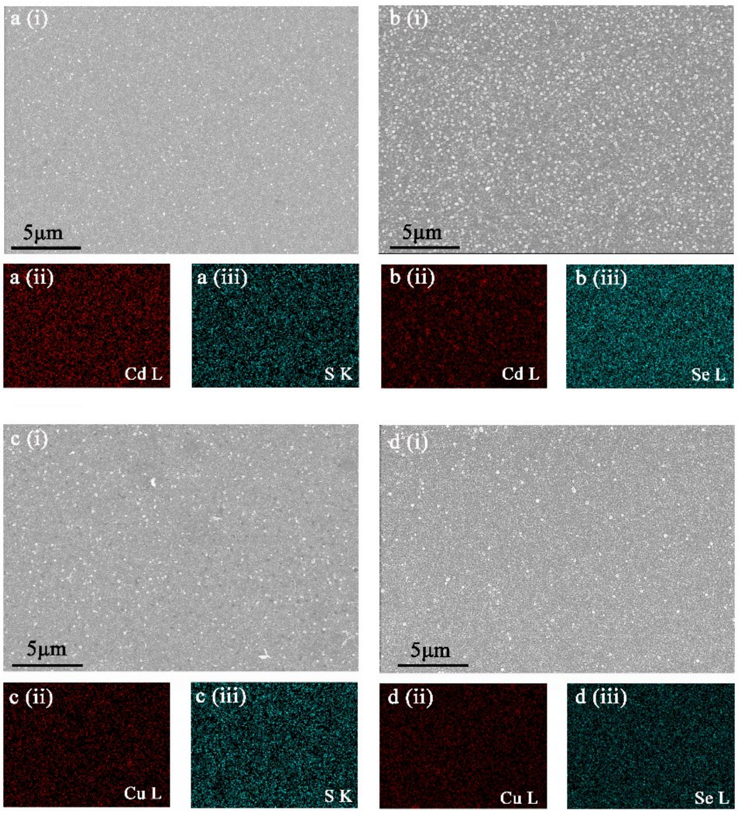

Figure 3S SEM images and EDS mapping of CdS (a), CdSe (b), Cu_2S (c) and Cu_2Se (d) thin film.

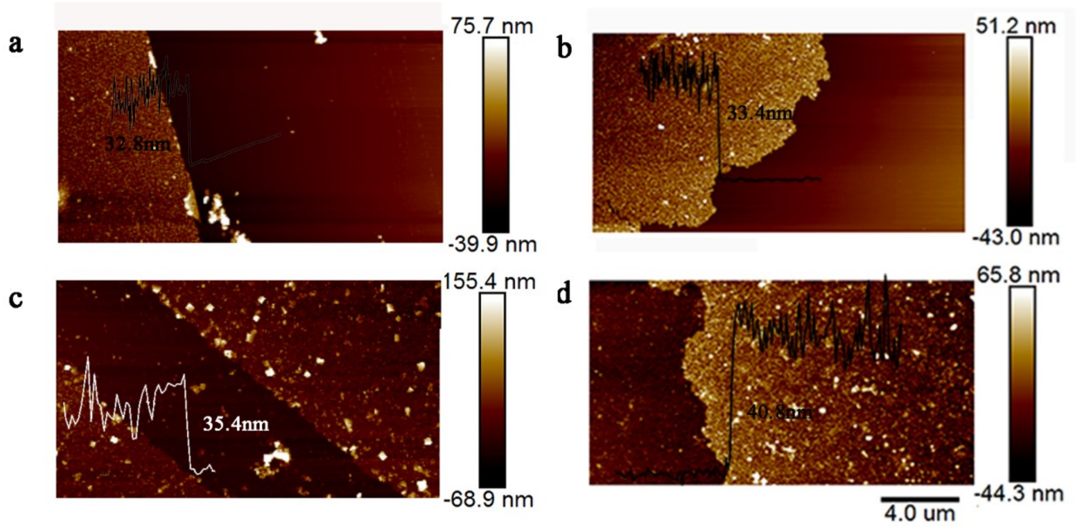

Figure 4S The height of as-prepared CdS(a), CdSe(b), Cu_2S(c) and Cu_2Se(d) thin films on sapphires when applying 17.5nm Ag thin films as precursors.

Table 2S Lattice Parameters and Crystal Structures of substrate and as-prepared thin films

Material	Crystal system	Lattice parameter
Sapphire	Hexagonal	a =4.47 c=13.00
CdSe	Hexagonal	a=4.29 c=7.010
Cu_2Se	Cubic	a=b=c=5.76
CdS	Hexagonal	a=4.14 c=6.72
Cu_2S	Hexagonal	a=3.95 c=6.78

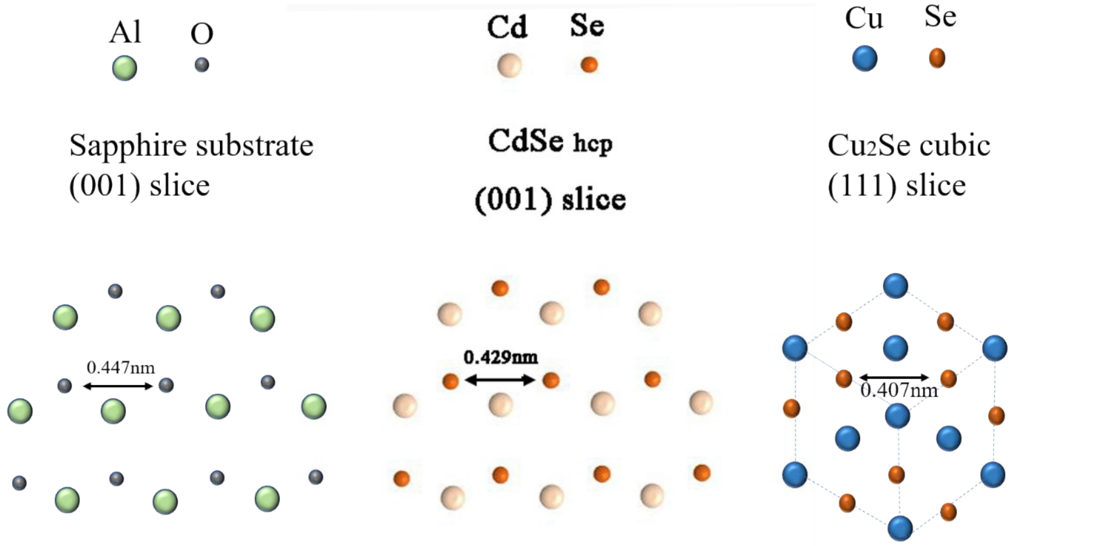

Figure 5S 2D unit cells of sapphire (001), CdSe (001) and Cu_2Se (111) slices displaying the stacking of the crystal structures.

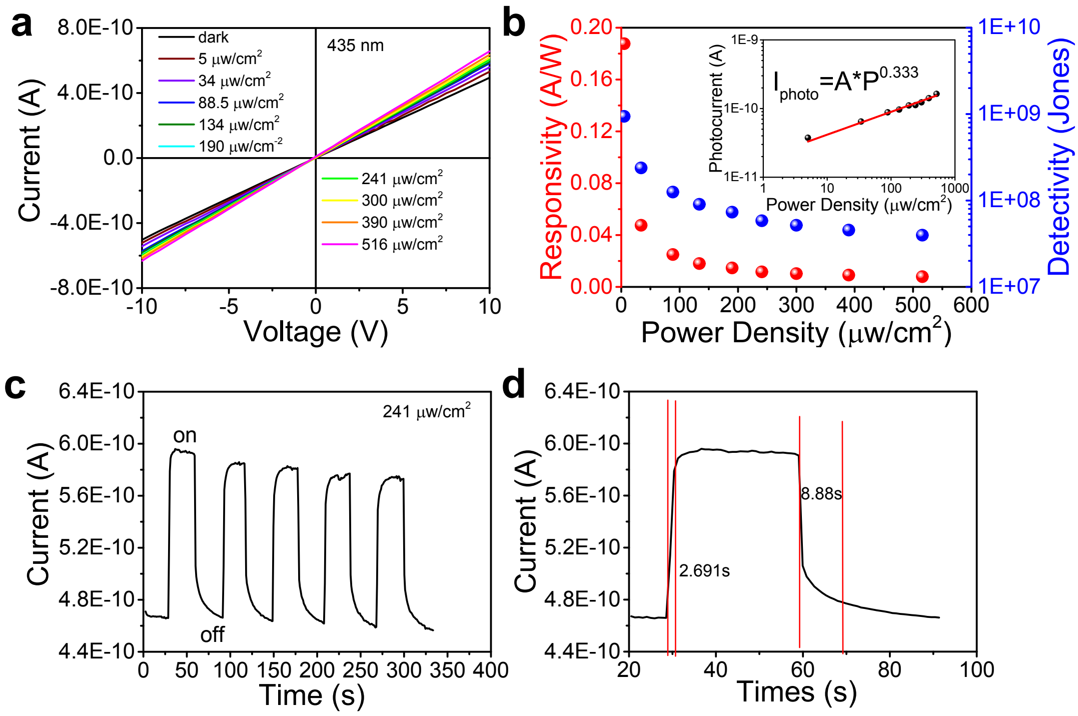

Figure 6S (a) The I-V curves of CdS thin film photodetector in dark and illumination condition at room temperature. (b) Responsivity and detectivity versus light intensity with the bias voltage of 10V. Inset：photocurrent as function of illumination power density. (c) Photocurrent response of CdS thin film photodetector upon 241 μw/cm2 illumination measured for the light-on and light-off conditions with the bias voltage of 10V. (d) A single cycle photocurrent response of CdS thin film photodetector.

Table 3S Room temperature photoelectrical properties of CdS and CdSe films prepared by different methods.

Sample	R	D*	reference
CdSe thin film	0.486 A/W	5.5*10^{11}Jones	Our work
CdS thin film	0.187 A/W	10^9Jones	Our work
CdS thin film	0.0629 A/W(532nm)	5*10^{11}Jones	Ref[1]
CdSe(mixed with MEH-PPV)	0.2 A/W(514nm)	-	Ref[2, 3]
CdSe quantum-dot film	0.068 A/W (560nm)*	10^5 Jones	Ref [4]
CdSe	7.33 A/W(638nm) 8.93 A/W (520nm)	>10^{13} Jones	Ref [5]

CdSe single-plates	18 A/W (402nm) 500A/W(450nm)	Ref [6]

Table 4S Room temperature electrical properties of Cu_2S and Cu_2Se thin films prepared by different methods.

Sample	σ	μ	reference
Cu_2S in our work	75 S/cm	536.9	Our work
Cu_2Se in our work	663 S/cm	cm^2/（V*s）	Our work
$Cu_{1.95}Se$	130 S/cm	1411.8	Ref[7]
$Cu_{2-x}S$	75 S/cm	cm^2/（V*s）	Ref[8]
Cu_2S	127 S/cm	7.62 cm^2/（V*s）	Ref[9]
Cu_2Se	1168 S/cm	1.12 cm^2/（V*s	Ref[9]
$Cu_{2-x}Se$	890-1380 S/cm	2.4 cm^2/（V*s）	Ref[10]
Cu_2Se	~10^3 S/cm	3.9 cm^2/（V*s）	Ref[11]
Cu_2Se	$1.1*10^3$ S/cm		Ref[12]
		10.4 cm^2/（V*s）	

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