Supporting Information for

*In-situ* fabrication of Cu$_2$ZnSnS$_4$(Se$_4$) nanoflake thin films on both rigid and flexible substrates

Xuezhen Zhai$^{1,2}$, Huimin Jia$^1$, Yange Zhang$^1$, Yan Lei$^1$, Jie Wei$^{1,2}$, Yuanhao Gao$^1$, Junhao Chu$^2$, Weiwei He$^{1,3}$, Jun-jie Yin$^3$, Zhi Zheng$^1$*

$^1$Key Laboratory of Micro-Nano Materials for Energy Storage and Conversion of Henan Province and Institute of Surface Micro and Nano Materials, Xuchang University Henan 461000, China

$^2$Key Laboratory of Polar Materials and Devices, Ministry of Education. Department of Electronics, East China Normal University. 500 Dongchuan Road, Shanghai 200241, China

$^3$Center for Food Safety and Applied Nutrition, U.S. Food and Drug Administration, College Park, MD 20740, USA

Corresponding Authors: E-mail: zhengzhi99999@gmail.com
zzheng@xcu.edu.cn
Figure. S1 XRD patterns of the CZTS nanocrystalline thin films samples prepared for 18 h at 250 °C on stainless steel substrates. The thicknesses of CuSnZn alloy layers were 100 nm~400 nm.
**Figure. S2** Raman spectra of the CZTS nanocrystalline thin films samples prepared for 18 h at 250 °C on stainless steel substrates. The thicknesses of CuSnZn alloy layers are 100 nm–400 nm.

**Figure. S3** XRD patterns of the CZTSe nanocrystalline thin films samples prepared at 230–270°C for 18 h on stainless steel substrates. The thickness of CuSnZn alloy layer is 400 nm.
Figure S4 XRD patterns of the CZTSe nanocrystalline thin films samples prepared for 18h~24h at 250 °C on stainless stell substrates. The thickness of CuSnZn alloy layer is 400nm.
**Figure S5** Raman spectra of the CZTSe nanocrystalline thin films samples prepared for 18 h and 24 h at 250 °C on FTO substrates.

**Figure S6** UV-vis-NIR absorption spectra of the CZTS thin film prepared at 230°C, 240°C and 250°C for 18 h (a) and the corresponding $(\alpha h\nu)^2$ vs. $h\nu$ curve (b).

**Figure S7** UV-vis-NIR absorption spectra of the CZTS thin film prepared at 250°C for 6 h, 18 h and 24 h (a) and the corresponding $(\alpha h\nu)^2$ vs. $h\nu$ curves (b).
Figure S8 SEM images of the original and solvothermal treated alloy surface.