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Supplementary material for

Intrinsic lamellar defects containing atomic Cu in Cu₂X (X=S, Se) thermoelectric materials

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Figure S1. Compositional analysis of the lamella defects by EDS in Cu₂S and Cu₂Se:
(a) HAADF image, Cu and S EDS maps in Cu₂S, respectively, obtained with conditions of probe size in UHR mode. The absence of Cu elements at the lamella defects can identified by the weaker signal intensity. However, the undulation of the S element is not obvious. (b) HAADF image and elemental maps of Cu and Se in Cu₂Se, respectively, obtained with conditions of probe size in HR Mapping mode. At the defects of Cu₂Se, the absence of copper accompanied by an enrichment of selenium are visualized.



Figure S2. Experimental ELNES Cu-L₂₃-edges of standard Cu metal and Cu₂O. The Cu metal (99.98%) was sampled by ion milling. The Cu₂O (99.9%) was ground and dispersed on a nickel mesh with microporous carbon film. The spectra were acquired in STEM using spot modes with dual EELS. The convergence semi-angle, the collection angles and entrance aperture were the same as those in all EELS acquisition of Cu₂S_{0.5}Se_{0.5}. The energy dispersions were all 0.1eV/channel in spectra of Cu metal and Cu₂O. The spectra are presented after background subtraction using the power law model and smoothed under a condition of w=2 using Gatan Micrograph software package.



Figure S3. The core-loss regions of EEL spectra in lamella defects and matrix obtained from other areas of the $Cu_2S_{0.5}Se_{0.5}$ sample. (a), (b) and (c) are HAADF

images where the regions for EELS are framed and the EEL spectra are presented in (d), (e) and (f), respectively.