Supporting Materials for

Residual stress induced tension-compression asymmetry of gradient nanograin copper

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Figs. S1 and S2
Fig. S1. Schematic illustration of the residual stress measurement process by using XRD method. \( \psi \) is the tilting angle of the normal direction of the GNG rod sample surface (i.e. ND direction) relative to the plane with X-ray source and detector (red), \( \theta \) is the incident angle or Bragg diffraction angle of \( \{420\} \) crystallographic plane used in this study and \( \sigma_r \) is the residual stress along the axial direction of GNG Cu sample.

Fig. S2. (a) The typical X-ray diffractogram of the \( \{420\} \) crystallographic plane for the microstructure at the depth of 40 \( \mu \text{m} \) in GNG Cu samples with different fatigue cycles \( (N) \) at \( \psi = 35.3^\circ \). The insert is the magnification of the dashed rectangle showing that the position of the diffraction peaks \( \{420\} \) for sample with the residual stress is slightly shifted, relative to that without residual stress (the dashed line). (b) Variation of measured 2\( \theta \) as a function of \( \sin^2\psi \) for the microstructure at a depth of 40 \( \mu \text{m} \) in GNG Cu samples with different fatigue cycles \( (N) \).