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Nanometer Scale Phase Separation and Chemical Inhomogeneity in the Iron Chalcogenide Superconductor $\mathbf{Fe_{1+y}Te_xSe_{1-x}}$ HEFEI HU, JIAN-MIN ZUO, University of Illinois at Urbana-Champaign, JINSHENG WEN, ZHIJUN XU, ZHIWEI LIN, QIANG LI, GENDA GU, Brookhaven National Laboratory, WAN KYU PARK, LAURA GREENE, University of Illinois at Urbana-Champaign — We report direct evidences of phase separation and chemical inhomogeneity in $Fe_{1+y}Te_xSe_{1-x}$ single crystals from scanning transmission electron microscopy (STEM) and electron energy loss spectroscopy (EELS). In STEM, images recorded using an annular dark field (ADF) detector show characteristic nanometer scale patterns of phase separation from the Z dependent contrast. The separation was observed in both non-superconducting samples with excess iron as well as superconducting samples. Using the line scan EELS technique, we determined ∼20%, or less, fluctuation in Te concentration from the local average compositions by integrating the intensity of the Te-$M_{4,5}$ edge. The energy-loss near-edge structure (ELNES) of the Fe-$L_{2,3}$ edge changes as the composition varies, especially the L_3 and L_2 ratio, which is sensitive to the d-state occupancy of the Fe atom. The results suggest a miscibility gap in the $Fe_{1+y}Te_xSe_{1-x}$ system and changes in the d-electron states at the nanometer scale from the separated phases.

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