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**Thickness Dependence Study of Superconducting Phase Transition in Atomically-Thin $FeTe_{1-x}Se_x$ Sheets** CHUNLEI YUE, XUE LIU, JIN HU, ZHIQIANG MAO, JIANG WEI, Tulane University, ANA SANCHEZ, University of Warwick — Different to other unconventional superconductors, iron chalcogenide $FeTe_{1-x}Se_x$ (x˜0 to 1) has a unique layered crystal structure, which makes atomically-thin single-crystal sheets achievable by micro-mechanical exfoliation. By using high resolution transmission electron microscopy, we found that exfoliation-prepared $FeTe_{1-x}Se_x$ sheets with thickness above 10nm exhibit excellent air stability. To obtain $FeTe_{1-x}Se_x$ sheets below 10nm with uncompromised crystal quality, crystal thinning with electrochemical etching technique that is based on the chemically inert ionic liquid has been experimented. The high crystal quality from obtained thinner sheets is characterized by atomic force microscopy and low-temperature transport measurements. We have observed that the onset transition temperature shifts continuously towards lower temperature with decreasing thickness. With the combination measurements of temperature-dependent resistance (R-T) and magnetoresistance (R-H), it can be clearly identified that four distinct transition stages, including Ginzburg-Landau fluctuation, BKT transition, finite size dominated region and superconducting region, exist in atomically-thin $FeTe_{1-x}Se_x$ sheets at different temperature range. Moreover, inhomogeneous nanoscale superconducting islands caused by the random lattice distribution of Te and Se atoms may introduce another factor that affects the density of vortices. Finally, a comprehensive phase diagram including sample thickness as the extra dimensionality is presented.

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