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Ultra-low thermal conductivity in disordered, layered tungsten diselenide CATALIN CHIRITESCU, DAVID CAHILL, University of Illinois at Urbana-Champaign, NGUYEN NGOC, DAVID JOHNSON, University of Oregon, ARUN BODAPATI, PAWEL KEBLINSKI, Rensselaer Polytechnic Institute, PAUL ZSCHACK, Argonne National Lab — Ultra low thermal conductivity of tungsten diselenide (WSe_2) thin films is achieved by controlling order and disorder of two dimensional WSe_2 sheets. We prepared highly textured nanocrystalline WSe_2 films by modulated elemental reactant (MER) method. Synchrotron X-ray diffraction shows the WSe_2 sheets are well aligned with the Si (100) substrate and the films have completely random crystalline orientation in the a-b plane. The cross-plane thermal conductivity of thin films of WSe_2 is as small as 0.05 W/m-K at room temperature, 30 times smaller than the c-axis thermal conductivity of single-crystal WSe_2 and a factor of 6 smaller than the predicted minimum thermal conductivity for this material. Molecular dynamics simulation on model structures suggests that the ultra-low thermal conductivity in layered, disordered crystals is a general phenomenon and not restricted to WSe_2. Ion irradiation of the samples disrupted the layered structure and the crystallinity of the WSe_2 sheets and lead to an increase with a factor of 3 in thermal conductivity. We attribute the ultra-low thermal conductivity to the localization of lattice vibrations induced by the random stacking of two-dimensional crystalline WSe_2 sheets.

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