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Thermal Conductivity of Nanocrystalline Silicon Prepared by Plasma-Enhanced Chemical-Vapor Deposition[1] BATTOGTOKH JUGDERSUREN, Sotera Defense Solutions, XIAO LIU, Naval Research Laboratory, BRIAN KEARNEY, DANIEL QUEEN, Natl Research Council, THOMAS METCALF, JAMES CULBERTSON, CHRISTOPHER CHERVIN, Naval Research Laboratory, MICHAEL KATZ, Natl Research Council, RHONDA STROUD, Naval Research Laboratory — Nanocrystallization by ball milling has been used successfully to reduce the thermal conductivity of silicon-germanium alloys (SiGe) and turn them into useful thermoelectric materials at a temperature of a few hundred degrees C. Currently the smallest grain sizes in nanocrystalline SiGe are in the 10 nm range. Germanium is added to scatter short wavelength phonons by impurity scattering. In this work, we report a record low thermal conductivity in nanocrystalline silicon prepared by plasma-enhanced chemical-vapor deposition. By varying hydrogen to silane ratio, we can vary the average grain sizes from greater than 10 nm down to 3 nm, as determined by both the high resolution transmission electron microscopy and X-ray diffraction. The values of thermal conductivity, as measured by the 3ω technique, can be correspondingly modulated from that of ball-milled nanocrystalline SiGe to a record low level of 0.3 W/mK at room temperature. This low thermal conductivity is only about 1/3 of the minimum thermal conductivity limit of silicon. Possible causes of such a large reduction are discussed.

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