American Mineralogist, Volume 93, pages 1306–1311, 2008

Single-crystal elastic properties of $(Mg_{0.987},Fe_{0.013})O$ to 9 GPa

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Abstract

The single-crystal elastic moduli of $(Mg_{0.987},Fe_{0.013})O$ were measured by Brillouin spectroscopy in a diamond-anvil cell at high pressures to 9 GPa at room temperature. The ambient-pressure single-crystal elastic moduli are (1) C_{11} = 291.2(3.0) GPa; (2) C_{12} = 96.1(2.0) GPa; and (3) C_{44} = 151.9(2.0) GPa. From the single-crystal moduli, the aggregate elastic moduli are calculated to be adiabatic bulk modulus K_{S0} = 161.1(3.0) GPa, the Voigt bound of the shear modulus is G_V = 130.0(2.0), and the Reuss bound G_R = 124.2(2.0) GPa, giving a Voigt-Reuss-Hill average G = 127.1(2.0) GPa. We find that the addition of 1.3 mol% of Fe has a surprisingly large effect on the aggregate shear modulus, decreasing the room-pressure value by 2.4% as compared to Brillouin data for periclase (MgO) measured with the same technique. The adiabatic bulk modulus also decreases by 1.3%, although this decrease is within the mutual uncertainties of the measurements. Our results confirm significant non-linearity in single-crystal elastic moduli C_{11} and C_{44} and the aggregate shear modulus G of magnesiowüstite in the Mg-rich end. The pressure derivative of the bulk modulus K_S' = 4.2(2), as determined by a third-order finite-strain fit, is about 9% higher than the Brillouin results for the MgO end-member, whereas the pressure dependence of the shear modulus G' = 2.3(1) is found to be identical to that of periclase. The measurements demonstrate that even a small amount of Fe (1.3 mol%) has a measurable effect on the elastic properties of MgO-FeO solid solutions.

Keywords: Elastic properties, high pressure, Brillouin interferometry, magnesiowüstite