

were used to obtain elastic constant measurements as a function of temperature. A third crystal oriented along [100] was used to measure the elastic constant C_{11} directly.

The elastic constants were measured by a buffer technique.⁽⁷⁾ Adoption of the buffer technique eliminates both the transit time error and the necessity of applying a transducer directly on the soft metal. According to this method the transducer and sample are cemented at opposite ends of a buffer rod. A pulse propagated through the rod is partially reflected and partially transmitted at the buffer-specimen interface. The transit time measured is then the true transit time. In this work magnesium served quite well as the buffer due to the desirable acoustic impedance reflection and transmission coefficients which exist between a magnesium-sodium interface.

A silicone release agent, Dow Corning 7 Compound, was used as a bond between both the quartz and magnesium and the magnesium and sodium. This seal, which does not react with sodium, was fluid at temperatures below that of the melting point of sodium so that thin seals could be made without introducing distortions, glassy at low temperatures to compensate for the relative thermal expansion differences involved, and rigid enough to provide good acoustic coupling for shear waves at the temperatures desired.

Transit time measurements for all three wave propagations were taken at liquid nitrogen and dry ice temperatures. In addition, measurements were taken at 20° temperature intervals between 78°K and 195°K. These intermediate temperatures were determined by placing an iron-constantan thermocouple in good thermal contact with the aluminum cartridge which contained the buffer assembly. About 2 hr were required to go from 78° to 195°K. The round trip transit times measured were of the order of 6, 10 and 28 μ sec for longitudinal, fast shear, and slow shear waves respectively for a 1 cm sample.

At 295°K sample 1 had a length of 1.34 cm and sample 2 a length of 1.05 cm. The sample lengths were measured at room temperature with a micrometer and corrections appropriate to the measuring temperature were made using the thermal expansion data of QUIMBY and SIEGEL.⁽⁹⁾

The elastic constants were calculated from the density, transit time, and sample length and plotted

as a function of temperature. From these graphs a set of elastic constants were chosen for each 20°K temperature interval. The temperatures selected were those for which a complete set of measurements as described was obtained for the two [110] samples. In addition, new seals were placed on each of these crystals and the measurements repeated. The velocities obtained in various runs always agreed within 1%. A third crystal was measured at 78°K and the results also agreed with the data reported here. In addition, longitudinal velocities were measured as a function of temperature on a crystal oriented along [100] and are reported in the next section.

RESULTS

The elastic constants are related to the acoustic wave velocities in the [110] direction by the following equations:

$$\begin{aligned} C_n &= (C_{11} + C_{12} + 2C_{44})/2 = \rho v_2^2 \\ C &= C_{44} = \rho v_5^2 \\ C' &= (C_{11} - C_{12})/2 = \rho v_4^2 \end{aligned} \quad (1)$$

where ρ is the density, v_2 is the longitudinal velocity, v_5 is the fast shear velocity with particle motion in the [001] direction, and v_4 is the slow shear velocity with particle motion in the $[\bar{1}10]$ direction. The adiabatic bulk modulus, B_s , and the stiffness C_{11} and C_{12} can be obtained by combining the directly measured quantities in the following way:

$$\begin{aligned} B_s &= \rho v_2^2 - \rho v_5^2 - \rho v_4^2/3 = (C_{11} + 2C_{12})/3 \\ C_{11} &= \rho v_2^2 - \rho v_5^2 + \rho v_4^2 \\ C_{12} &= \rho v_2^2 - \rho v_5^2 - \rho v_4^2 \end{aligned} \quad (2)$$

The elastic constants shown in Table 1 have been calculated using equations (1) and (2).

Table 2 lists the adiabatic bulk modulus B_s , along with the isothermal bulk modulus B_T . The latter was computed from B_s using the approximate relation

$$B_T \approx B_s \left(1 - \frac{TV\beta^2 B_s}{C_p} \right)$$

where V is the molar volume, β is the volume coefficient of expansion and C_p is the molar heat capacity. The values of V and β were obtained