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Elastic Constants of Silicon Carbide

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ELASTIC constants of silicon carbide were measured on relatively porous sintered polycrystalline specimens because it is difficult to prepare large enough specimens of essentially theoretical density for the usual ultrasonic techniques. Thus the elastic constants were measured by Lang[1] on specimens of 96.5 to 97.5% theoretical density and by Wachtman and Lam[2] on a specimen of 96% theoretical density. Einspruch and Clairborne[3] also reported values for Young's and shear moduli, but they did not report the bulk density of their specimen. For the ultrasonic interferometry technique for measuring longitudinal and shear velocities, a specimen 1 cm long is adequate. It is possible to determine the elastic constants of ceramic materials which can be sintered to very near theoretical density as small specimens.

A specimen of hot-pressed polycrystalline SiC 0.9563 cm in diameter and 1.2734 cm long was obtained from The Carborundum Company. X-ray diffraction revealed that the specimen was α-SiC. The measured density was 3.181 g/cm^3 or 99.0% of the theoretical density of SiC (3.21 g/cm^3). The longitudinal and shear velocities were measured by pulse superposition, the details of which were discussed elsewhere.[4]

The elastic moduli, calculated from the measured velocities and density, are given in Table I.

The values of the Young's and shear moduli reported in the literature are plotted in Fig. 1 as a function of porosity. Extrapolating the data to zero porosity yields 1960 kbars and 4580 kbars for shear and Young's moduli, respectively. The bulk modulus and Poisson's ratio at zero porosity extrapolate to 2302 kbars and 0.168, respectively.

Table I. Elastic Moduli of Hot-Pressed Polycrystalline SiC*

Shear velocity	v_s	7.69 km/sec
Longitudinal velocity	v_l	12.21 km/sec
Shear modulus	ρv_s^2	1883 kbars
Young's modulus	$\rho v_s^2(3v_l^2 - 4v_s^2)/(v_l^2 - v_s^2)$	4406 kbars
Bulk modulus	$\rho(v_l^2 - {}^4/_3 v_s^2)$	2234 kbars
Poisson's ratio	$(v_l^2 - 2v_s^2)/2(v_l^2 - v_s^2)$	0.170

* 3.181 g/cm^3.

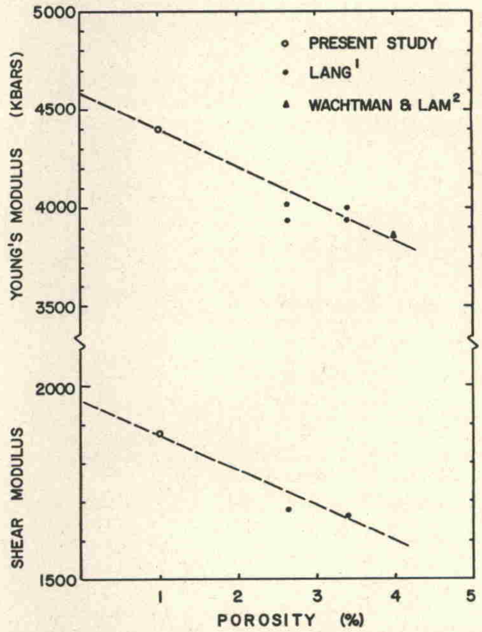

Fig. 1. Porosity dependence of elastic moduli for SiC.

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Revised Data on Polycrystalline Magnesium Oxide[1]

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In an earlier publication [*Anderson and Schreiber*, 1965], the pressure derivatives of the elastic moduli of a specimen of polycrystalline MgO were presented. Subsequent to this report, results obtained from a specimen of single crystal MgO were presented [*Anderson and Andreatch*, 1966], and a discrepancy between the results obtained from the polycrystalline and the single-crystal specimens was noted. In particular, the adiabatic pressure derivatives of the bulk modulus were reported to be 3.92 and 4.49 for the polycrystalline and single-crystal specimens, respectively.

The polycrystalline specimen employed in the experiment was of unusual quality, having essentially theoretical X-ray density and being transparent. This quality was achieved in the fabrication process by the addition of several per cent of a fluoride compound to the raw material before hot pressing. Addition of a fluoride is recognized as enhancing the results of hot pressing by increasing the rate of vacancy diffusion and hence sintering without excessive grain growth. Only a few ppm of fluorine were found in a spectroscopic analysis of the finished specimen.

Comparison of the *P* and *S* velocities measured on the polycrystalline specimen with averaged single-crystal values from data available in the literature [*Durand*, 1936; *Bhagavantam*, 1955; *Susse*, 1961; *Chou and Whitmore*, 1961; *Chung et al.*, 1963, 1966; *Anderson and Andreatch*, 1966] suggested that the *P* velocity was higher than the Voigt-Reuss value obtained by averaging the single-crystal constants.

As a consequence, it was decided to procure a specimen of hot-pressed MgO that had similar acoustic quality but that had been prepared with no additions of any kind. Such a specimen was obtained through the generosity of the Avco Corporation, and the elastic properties and their pressure derivatives were determined for this specimen. The method and apparatus employed were the same as described earlier [*Anderson and Schreiber*, 1965]. The results obtained with this specimen are summarized in Table 1 and are compared with the results of the specimen previously reported.

As can be seen from Table 1, the principal discrepancies appear in the values of v_p and especially in the values of dv_p/dP (which differ by $\sim$10%), which give rise to the differences in the bulk modulus and its pressure derivative, the Poisson ratio, and the Grüneisen parameter. The agreement between the new data on polycrystalline MgO and the results derived from the measurements on a single crystal are quite good. The values of K and σ for the single crystal and the polycrystal are now reconciled. We recommend the value $K_s = 1622$ kb, as calculated from the single-crystal data, as the best value to use for MgO.

The reason for the discrepancy noted between the two polycrystalline specimens is not under-

TABLE 1. Comparison between Data Obtained on Single-Crystal and Polycrystalline Specimens of MgO

Property (Adiabatic Values)	Polycrystalline MgO		Single Crystal†
	Old*	New	
v_p, km/sec	9.7662	9.6605	9.681
v_s, km/sec	5.9635	5.9974	6.041
dv_p/dP, km/sec/kb	7.71×10^{-3}	8.66×10^{-3}	
dv_s/dP, km/sec/kb	4.35×10^{-3}	4.23×10^{-3}	
dK/dP	3.92	4.58	4.49
$d\sigma/dP$, kb^{-1}	5.63×10^{-5}	1.95×10^{-4}	2.86×10^{-4}
K, kb	1717	1624	1622
G, kb	1273	1288	1308
σ	0.203	0.186	0.182
γ_{LT}	1.596	1.511	1.498
ρ, g/cm^3	3.5800	3.5797	3.5833

* *Anderson and Schreiber* [1965].
† *Anderson and Andreatch* [1966].

[1] Lamont Geological Observatory Contribution 1172.

stood. Recent data reported by *Chung* [1966], obtained on a sample of hot-pressed MgO (Kodak IRTRAN), which was also prepared with an additive, give results in agreement with the results we reported previously. We are inclined to think that any additives used in the preparation of polycrystals may shift the elastic constants. The source of the difference in results remains under study.

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