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ABSORPTION OF COMPRESSIONAL WAVES IN SOLIDS FROM 100 TO 1000 Mc/sec

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We have determined the absorption of compressional waves in crystal quartz [X-direction], fused silica, germanium [100], and silicon [111]: the crystallographic directions specify the direction of propagation. Measurements were made by the "pulse technique" using guided waves in cylindrical specimens.[1-3] The dependence of the amplitude absorption coefficient on frequency is shown in Figs. 1-4.

In contrast to the findings of Granato and Truell and their co-workers[4-7] for germanium, we observed little difference between the absorption values for five crystals of silicon from different sources. These had dislocation densities—revealed by etch pits—from a few hundred to over 10^4 per cm^2. Two specimens were n-type with average resistivities of 0.1 and 14 ohm-cm, and three were p-type with resistivities of 3.20 and 30 ohm-cm. The axis of each cylinder was within 3° of the [111] direction. The absorption values in all five specimens agreed to within ±5%.

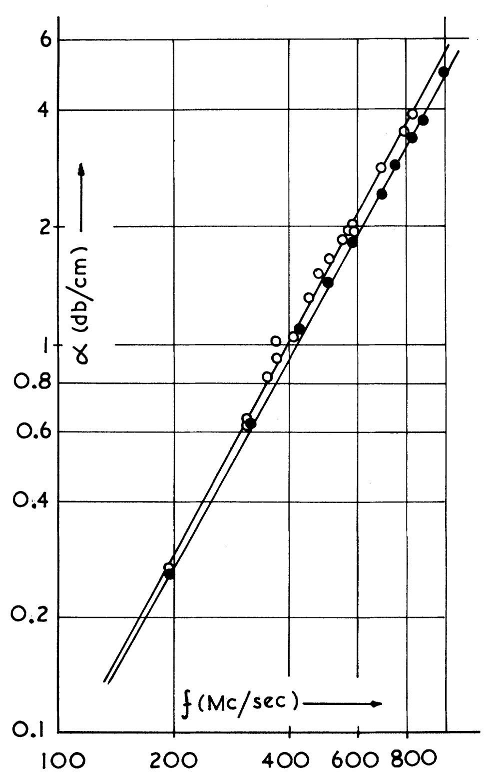

FIG. 1. Log(absorption coefficient) versus log(frequency) in crystal quartz. Propagation is along the X-axis. o = 20°C; • = -77°C. At 20°C, α is proportional to $f^{1.82}$

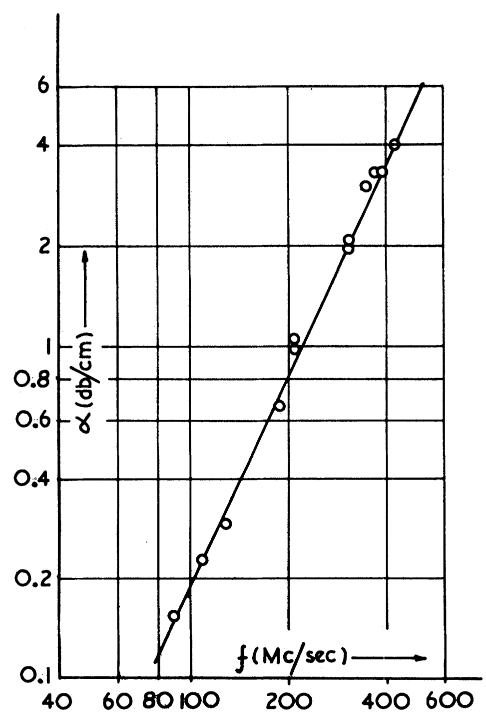

FIG. 2. Log(absorption coefficient) versus log(frequency) in fused silica (Thermal Syndicate, O.G. grade) at 18°C: α is proportional to $f^{2.12}$.

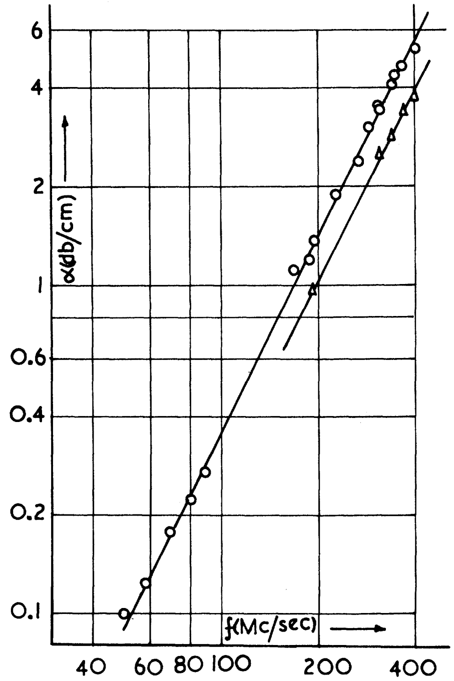

FIG. 3. Log(absorption coefficient) versus log(frequency) in germanium. Propagation is parallel to the [100] direction. o = 18°C; Δ = -158°C; the absorption is proportional to $f^{1.98}$ at 18°C.

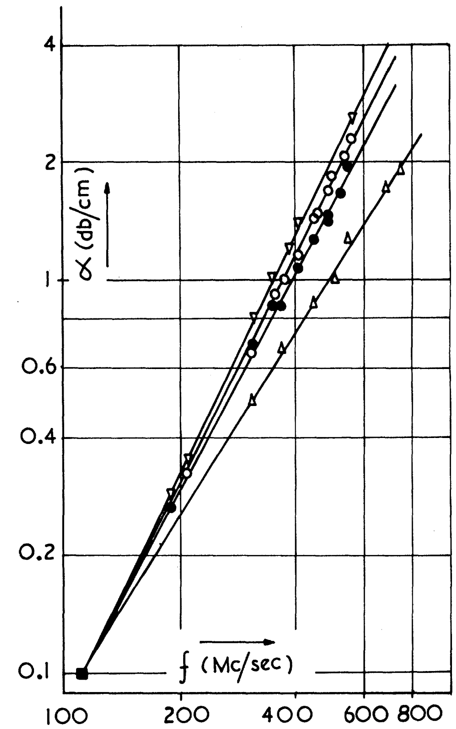

FIG. 4. Log(absorption coefficient) versus log(frequency) in silicon. Propagation is parallel to the [111] direction. ∇ = 197°C; o = 20°C; • = -77°C; Δ = -158°C. At 197°C, α is proportional to $f^{2.0}$ and at -158°C to $f^{1.54}$.

Granato and Truell[6] found a wide range of absorption values in different specimens of germanium; their lowest values are close to, but slightly higher than, our values (Fig. 3).

At 20°C the absorption coefficient, α, for silicon and for germanium is approximately proportional to the square of the frequency. As a rough approximation, this is also true for crystal quartz and fused silica.

The values for crystal quartz at 1000 Mc/sec give quantitative support to estimates which have been made using other techniques.[8,9] We are continuing this work.

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