

Table 2. piezoelectric constants

	e_{xx} (C m ⁻²)	$\partial e_{xx}/\partial \eta_x$ (C m ⁻²)	$\partial \ln e_{xx}/\partial \eta_x$
x-cut quartz ¹	0.1711 ± 0.00094	2.62 ± 0.048	15.3 ± 0.3
z-cut lithium niobate	1.80 ± 0.025	18 ± 6	10 ± 3

± indicates standard error except for nonlinear constants of lithium niobate which are maximum experimental errors. *x* and *xx* denote 1 and 11 for quartz and 3, and 33 for lithium niobate.

The linear and nonlinear constants of lithium niobate are compared to corresponding values obtained for x-cut quartz in Table 2. The nonlinear constant has a large (40 per cent) standard error; however, consideration of the maximum experimental error gives a maximum error of ± 30 per cent for this constant. It should be noted that even though the linear constants differ by an order of magnitude, the logarithmic derivatives with strain have approximately the same value. Thus, the magnitude of the nonlinear constants appears to depend upon the value of the linear constant. This observation is in agreement with recent observations by Lim *et al.*¹² of the electromechanical coupling associated with nonlinear interaction of

acoustic surface waves which involve contributions from a combination of tensor components. These authors found that materials with lower linear coupling constants exhibited lower nonlinear coupling constants. The present value for the nonlinear constant is also in good agreement with an estimate by Thompson and Quate,¹³ who utilized a microwave acoustic technique.

Acknowledgements — The author is pleased to acknowledge the excellent technical assistance of R.D. Jacobson and discussions with R.B. Thompson and C.F. Quate. R.M. Wolff was instrumental in locating materials utilized in the present investigation. I.J. Fritz provided a very helpful review of the manuscript.

REFERENCES

- GRAHAM R.A., *Phys. Rev. B*, **6**, 4779 (1972).
- INGRAM G.E. and GRAHAM R.A., *Proc. 5th Symp. on Detonation*, sponsored by ONR, held in August 1970; also available as Sandia Laboratories Reprint SC-R-72 2722.
- Shock induced conductivity in x-cut quartz has been studied extensively. See: GRAHAM R.A. and HALPIN W.J., *J. appl. Phys.* **39**, 5077 (1968) and GRAHAM R.A. and INGRAM G.E., *J. appl. Phys.* **43**, 826 (1972).
- WARNER A.W., ONOE M. and COQUIN G.A., *J. Acoust. Soc. Am.* **42**, 1223 (1967).
- SMITH R.T. and WELSH F.S., *J. appl. Phys.* **42**, 2219 (1971).
- KOROLYUK A.P., MATSAKOV L. YA. and VASIL'CHENKO V.V., *Soviet Phys. Crystallogr.* **15**, 893 (1971).
- BECHMANN R., *Phys. Rev.* **110**, 1060 (1958).
- NASSAU K., LEVINSTEIN H.J. and LOIANCONO G.M., *J. Phys. Chem. Solids* **27**, 989 (1966).
- EVLANOVA N.F. and RASHKOVICH L.N., *Soviet Phys. Solid State* **13**, 223 (1971).
- BYER R.L., YOUNG J.F. and FEIGELSON R.S., *J. appl. Phys.* **41**, 2320 (1970).
- CARLSON R.L., *IEEE Ultrasonics Symposium*, 1972.
- LIM T.C., KRAUT E.A. and THOMPSON R.B., *Appl. Phys. Lett.* **20**, 127 (1972).
- THOMPSON R.B. and QUATE C.F., *J. appl. Phys.* **42**, 907 (1971).

Auszug — Es werden Messungen der piezoelektrischen Polarisierung von Lithiumniobat-z-Schnitt für dynamische Druckspannungen von $8,9 \times 10^{-4}$ bis 6×10^{-3} durchgeführt. Es werden Werte der linearen piezoelektrischen Konstante e_{33} und ihre Spannungsableitungen ermittelt. Es wurde festgestellt, dass die logarithmischen Spannungsableitungen der longitudinalen piezoelektrischen Konstanten des x-Schnitt Quarzes und z-Schnitt Lithiumniobats ungefähr gleich sind.