

tigue experimental data serve as the basis for these formulations. Unfortunately, these formulations are not fundamental, which makes it difficult to apply them generally. More work is needed to create thermomechanical fatigue lifetime reliability predictions based on the fundamental metallurgy of the solder joints.

**References**

1. *Science News*, **140** (1992) p. 182.
2. D. R. Frear, W. B. Jones, and K. R. Kinsman, *Solder Mechanics: A State-of-the-Art Assessment*, TMS Publications, Warrendale, PA (1991).
3. F. G. Yost, F. P. Ganyard, and M. M. Karnowsky, *Metall. Trans. A.*, **7A** (1976) p. 1141.
4. S. Kang, N. D. Zommer, D. L. Feucht, and R. W. Heckel, *IEEE Trans. Parts, Hybrids, and Packaging*, **PHP-13** (1977) p. 318.
5. D. R. Frear, PhD thesis, University of California-Berkeley, 1987.
6. H. N. Keller, *IEEE Trans. Comp. Hybrids and Manufac. Tech.*, **CHMT-4** (1981) p. 132.
7. D. Frear, D. Grivas, and J. W. Morris Jr., *J. Electron. Mater.*, **18** (1989) p. 671.
8. D. R. Frear and P. T. Vianco, "Intermetallic Growth and Mechanical Behavior of Low Melting Temperature Solder Alloys," *Metall. Trans. A.*, to be published.

9. D. R. Frear, F. M. Hosking, and P. T. Vianco, *Materials Developments in Microelectronics Packaging: Performance and Reliability* (ASM International, Metals Park, OH, 1991) p. 229.
10. R. E. Barlow and F. Proschan, *Mathematical Theory of Reliability* (John Wiley & Sons, New York, 1965).
11. P. J. Kay and C. A. MacKay, *Trans. Inst. Metal Finishing*, **54** (1976) p. 68.
12. J. R. Hulett, *Quarterly Reviews*, **18** (1964) p. 227.
13. A. D. Romig Jr., F. G. Yost, and P. F. Hlava, *Microbeam Analysis-1984*, (San Francisco Press, San Francisco, 1984).
14. T.-Y. Pan and W. L. Winterbottom, *Proc. ASME Winter Annual Mtg.* (1990).
15. J. H. Lau and G. Harkins, *Proc. IEEE 38th ECC Conf.*, **38** (1988) p. 23.
16. D. Frear, D. Grivas, and J. W. Morris Jr., *J. Electron. Mater.*, **18** (1989) p. 671.
17. L. C. Beavis, M. M. Karnowsky, and F. G. Yost, U.S. Patent No. 5,121,871.
18. D. R. Frear, W. B. Jones, J. W. Morris Jr., and Z. Mei, in *Manufacturing Processes and Materials Challenges in Microelectronic Packaging*, edited by W. T. Chen, P. Engle, and W. E. Jahsmann (ASME, AMD-131/EEP-1, 1991) p. 1. □

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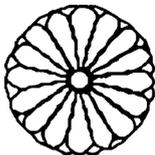
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