stress components are present. The magnitude of the thermal stresses, however, is reduced by the presence of glassy subinclusion in the particle by a factor Φ', inversely related to the volume fraction of subinclusion. Thus, for a given rubber content in the polyblend the level of thermal stresses decreases as more glassy polymer is transferred from the matrix into the dispersed phase.

Although our analysis is based on a very simplified model of the composite particle, we believe that the main effects of the sub-inclusions on thermal stress distribution and magnitude have emerged.

Acknowledgements

The authors wish to thank Professor F. Danusso for kind advice. This work was suppored by ANIC S.p.A., San Donato Milanese (Italy), with partial contribution of Consiglio Nazionale delle Ricerche, Roma, Italy.

References

1. G. H. DEWEY and J. O. OUTWATER, *Mod. Plastics* 37 (1960) 142.
2. D. B. BINNS, in "Science of Ceramics", Vol. 1, edited by G. H. Stewart, (Academic Press, New York, 1962) p. 315.
3. W. J. FREY and J. D. MACKENZIE, *J. Mater. Sci.* 2 (1967) 124.
4. J. A. SCHMITT, *J. Appl. Polymer. Sci.* **12** (1968) 533; *J. Polymer Sci.* **C30** (1970) 437.
5. R. H. BECK, S. GRATCH, S. NEWMAN and K. C. RUSCH, *Polymer Letters* 6 (1968) 707.
6. M. A. STETT and R. M. FULRATH, *J. Amer. Ceram. Soc.* 53 (1970) 5.
7. L. BOHN, *Angew. Makromol. Chem.* **20** (1971) 129.
8. see for example E. R. WAGNER and L. M. ROBESON, *Rubber Chemistry and Technology* **43** (1970) 1129.
9. G. LAMÉ, "Leçons sur la théorie... de l'élasticité" (Gauthier-Villars, Paris, 1852) as reported for instance by S. TIMOSHENKO and J. N. GOODIER, "Theory of Elasticity", 3rd Edn., (McGraw-Hill Kogakusha, New York, 1970) Ch. 12.

Received 30 December 1975
and accepted 10 February 1976

A. PAVAN
T. RICCÒ
Industrial Chemistry Department,
Macromolecular Chemistry
and Materials Section,
Polytechnic Institute,
20133 Milan, Italy

Comments on "Magnetic parameters of ferrite inclusions observed in magnesium oxide substrates used in nickel ferrite film growth"

In a recent paper [1], Tooke reports ferrimagnetic resonance measurements on ferrite precipitates produced by oxidation of thin films of $NiFe_2$ on MgO single crystal substrates at temperatures of the order of 1200° C and subsequent cooling to room temperature. The precipitates are shown to be coherent, with the [001] axis perpendicular to the plane of the substrate. The parameters g and K_1/M are determined by measuring the angular variation of the resonance field. The experimental values are $g = 2.000 \pm 0.004$, $K_1/M = -144 \pm 3$ G.

When discussing his results, the author states that the values above "are not consistent with nickel ferrite". This is expected, since the precipitates are formed after diffusion into the substrate [2] and should contain at least some magnesium ions. There remain two distinct possibilities: the inclusions might be either magnesium nickel ferrite ($Ni_{1-x}Mg_xFe_2O_4$), as suggested by Engin and Fitzgerald [2], or pure magnesioferrite ($MgFe_2O_4$). In this context, the experimental value of the g-factor ($g = 2.000$) provides an important clue. It is well known [3, 4] that the Ni^{2+} ion, having a non-zero orbital angular momentum, produces a significant increase in the g-factor relative to its free-electron value (2.0023). In ferrites with composition $Ni_{1-x}Zn_xFe_2O_4$, for example, the g-factor is 2.020 for $x = 0.8$ and increases rapidly with increasing nickel content [5]. On the other hand, the g-factor of magnesioferrite is close to 2.00, since Mg^{2+} is a non-magnetic ion [3, 4]. This seems to show that the inclusions have a very low nickel content. This is substantiated by the fact that the experimental value of the anisotropy parameter ($K_1/M = -144$ G) is consistent with pure magnesium ferrite with an inversion parameter corresponding to the temperature of the heat treatment. For $MgFe_2O_4$ specimens quenched in water from 1200° C, the experimental value is $K_1/M = -138$ G [6], certainly compatible with Tooke's results when the uncertainty in the temperature of the heat-treatment of his samples is

© 1976 Chapman and Hall Ltd. Printed in Great Britain.

taken into account.

The data reported in [1] seem, therefore, to indicate that the inclusions are pure or almost pure magnesioferrite, with a nickel content of not more than a few per cent.

References

1. A. O. TOOKE, *J. Mater. Sci.* **10** (1975) 1830.
2. R. ENGIN and A. G. FITZGERALD, *ibid* **9** (1974) 169.
3. K. J. STANDLEY, "Oxide Magnetic Materials" (Oxford University Press, London, 1972).
4. W. H. VON AULOCK, ed., "Handbook of Ferrite Materials" (Academic Press, New York, 1965).
5. T. OKAMURA, *Sci. Repts. Res. Inst. Tohoku Univ.* **A6** (1954) 89.
6. K. I. ARAI and N. TSUYA, *J. Phys. Chem. Solids* **34** (1973) 431.

Received 30 December 1975
and accepted 6 January 1976

RONALDO SERGIO DE BIASI
Seção de Ciência dos Materiais
Instituto Militar de Engenharia
Urca, Rio de Janeiro, Brazil

Acoustic emisison from microcracks during sliding contact

Microcracks may be readily formed in brittle solids under comparatively small normal forces by dragging an indenter, e.g. a hard particle, across the surface; this process is responsible for most of surface damage and resultant strength degradation of brittle materials [1–5]. Thus "scratch resistance" is an important mechanical property which provides a useful figure of merit for assessing material response to many damage and wear situations. The physical significance of scratch resistance has been examined through a variety of contrived scratch systems, one in particular, the fixed spherical indenter on a smooth plane surface has been widely studied both theoretically and experimentally [6–8]. A typical system is shown schematically in Fig. 1 and a resultant set of crescent shaped microcracks formed in the wake of a sliding sphere on a polished glass surface is shown in Fig. 2.

One of the experimental difficulties associated with scratch tests has traditionally been in characterizing the intensity of the scratch. The number of microcracks, or crack density, constitutes a reasonably measurable parameter, but often involves tedious and time consuming measurements from optical observations. Wilshaw and Rothwell [9] attempted to measure the individual microcracks as they formed, by detecting and autographically recording the number and intensity of the stress waves emitted during unstable crack extension. The current study examines the relationship between the size and density of the microcracks and the recorded emissions in greater detail than before; a significant reduction

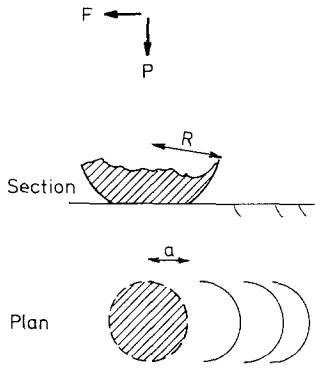

Figure 1 Diagram of a typical spherical sliding system, together with resultant microcracks. Normal load on the indenter, P, load on indenter parallel to surface, F, radius of indenter, R, radius of contact circle, a. Direction of indenter travel: from right to left.

in the emission strength with increasing microcrack density is observed and a physical explanation is provided.

The important variables involved in microcrack formation are illustrated schematically in Fig. 1. For a specific material with a uniform surface flaw size density distribution the fracture behaviour is determined by the contact stress field which, in turn, is governed by the applied load P on the indenter, the coefficient of sliding friction μ_K, the radius R of the indenter and the elastic properties of the indenter and work-piece (specimen). Surface roughness may also be an important parameter affecting μ_K, although in the present work this was not an important consideration since polished surfaces only were used. The experiments were carried out on mechanically polished blocks (50 m × 100 mm × 10 mm) of soda-lime-silica glass in a laboratory air atmosphere (25%

© *1976 Chapman and Hall Ltd. Printed in Great Britain.*