Letters

Wetting of glass-to-metal and glass-to-ceramic in water-vapour atmospheres

Glass-to-metal wetting has been the subject of great interest in the electronic and porcelain enamel industries. Work carried out at Berkeley [1] and Battelle [2] has contributed to an overall understanding, but no consistent theory explains the glass-to-metal wetting in all inorganic systems. For example, Volpe *et al.* [3] concluded that water vapour increased the wetting angle of sodium disilicate glass on platinum, indicating that water vapour may have been absorbed on the metal and reduced its surface energy. Parikh [4] on the other hand, has reported that the surface tension of glass is lowered by water vapour and that the lowering of surface tension is approximately proportional to the square root of the partial pressure of water vapour. Accordingly, lower angles are expected in wet atmospheres than in dry atmospheres. Thus it appears that wetting cannot be predicted from the simple Young's equation

$$\cos\theta = \frac{\gamma_s - \gamma_{sg}}{\gamma_g}$$

since the exact effect of water vapour on the energies of the substrate γ_s, the glass γ_g, and the substrate-glass interface γ_{sg} is not known.

An established technique for studying the factors that influence wetting is to investigate the behaviour of a sessile drop of glass on a substrate of the desired metal or ceramic under a variety of process conditions. This technique was used in the present investigation to study wetting of a borosilicate glass on ceramic and evaporated metal substrates.

The wetting angle equipment consisted of an optical system for viewing and photographing samples, and a small furnace with inlets and outlets provided for special atmospheres.

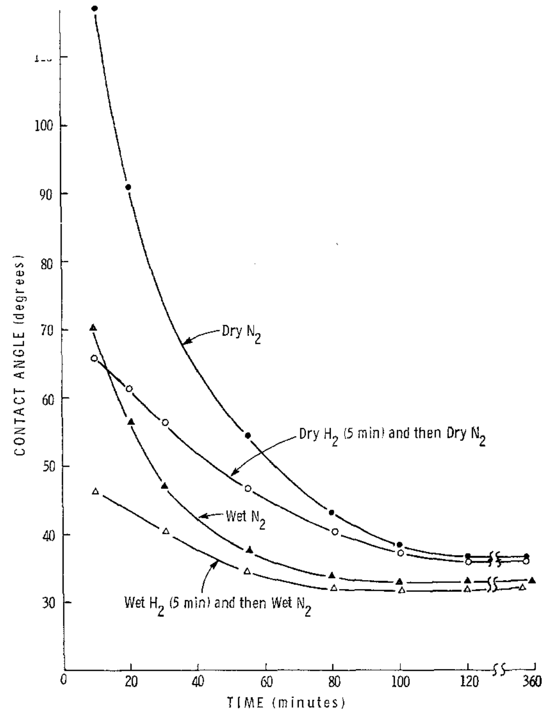

Figure 1 Wetting of borosilicate glass on 99.5% alumina ceramic in wet and dry atmospheres at 900° C.

Wetting-angle measurements of borosilicate glass on 99.5% alumina substrate at 900° C are given in Fig. 1 in wet (85% RH) and dry N_2 (30% RH), and in wet (85% RH) and dry H_2 (30% RH) followed by N_2. In both atmospheres, the wetting angles are always higher in dry gas than in wet gases. In addition, the wetting angles seem to reach equilibrium values more quickly in wet gases than in dry gases. Using Young's equation, since the equilibrium wetting angle in dry N_2 is 37°, we can calculate γ_{sg} (from γ_s = 1005 dyn cm^{-1}, γ_g = 300 dyn cm^{-1}) to be 755 dyn cm^{-1}. If we now assume, as a first approximation, that the interfacial energy is not affected as the atmosphere is changed from dry to wet, we can calculate γ_g to be 275 dyn cm^{-1}, which value is in general agreement with the surface energy measurements of Parikh for a wet atmosphere. This agreement between calculated surface energy of glass from reduction in wetting angle as the atmosphere is changed from dry to wet, and observed surface energy of glass by Parikh in a wet atmosphere implies that the lower wetting angles in wet atmospheres are mainly a result of lowering the surface energy of glass, and that neither the surface energy of the substrate nor the interfacial energy are markedly affected. A similar calculation for the surface energy of glass in wet H_2/N_2 gives a value of 280 dyn cm^{-1}.

Results shown in Fig. 2 for the wetting of borosilicate glass on 1000 Å chromium thin film

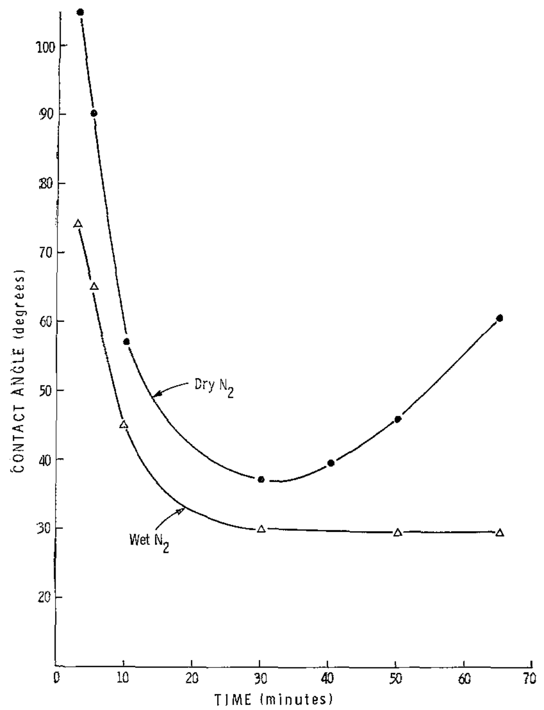

Figure 2 Wetting of borosilicate glass on evaporated thin film of chromium in wet and dry N_2 at 900° C.

in dry and wet N_2 indicate that introducing a wet atmosphere is an effective way of lowering and maintaining the wetting angle. Dry nitrogen-containing atmospheres, on the other hand, seem to raise the wetting angle with prolonged time. The mechanism contributing to this increase in wetting angle is not known for certain, but it coincides with the development of mostly nitrides and a small amount of oxides in the surface of the film [5]. Whereas a continuous layer of Cr_2O_3 is always present in the surface of the film in wet atmospheres, both oxides (oxides having been formed from 3 to 5 ppm O_2 impurity in N_2) and nitrides are present in dry atmospheres. This implies that chromium oxides contribute to better wetting than nitrides. Unfortunately, no data are available to prove or disprove the effect of chromium nitrides.

It appears that water vapour lowers the wetting angles in both glass-ceramic and glass-metal systems. The mechanism by which this occurs is not known for certain, but it appears to be largely due to lowering surface energy of glass by water vapour.

References

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R. R. TUMMALA
B. J. FOSTER
Glass Development Department,
IBM East Fishkill, New York, USA

Fibre orientation distribution in short fibre reinforced plastics

A knowledge of the fibre orientation distribution is an essential pre-requisite in seeking to predict the deformation behaviour of a short-fibre reinforced plastic. For asbestos fibres, wide-angle X-ray diffraction techniques have been applied with some success to the determination of the variation of fibre orientation distribution with position in an injection moulding [1]. This powerful technique cannot be applied in the important area of short glass-fibre reinforced thermoplastics and alternative techniques must be sought.

The texture that is often visible in mouldings when examined in transmitted light or by (macro) radiography is not necessarily related to the orientation of the well-dispersed fibres that are primarily responsible for the enhancement of the mechanical properties. Such texture or flow markings have been found to be misleading when predicting mechanical response [2].

Examination of individual fibre orientation has been widely performed using microtomed sections or surfaces prepared by the metallographic polishing technique. The latter technique is far more widely used since it is not restricted to translucent mouldings and causes less damage to the fibres and less disruption of their orientation. It is, however, a time consuming and laborious task with the results sometimes disappointing due to lack of contrast between the fibre and matrix.