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VANADIUM GLASS SWITCHES FOR TEMPERATURE CONTROL

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Glasses can be obtained over a wide range of compositions in the system V_2O_5-P_2O_5, from P_2O_5 itself to over 90 mol% V_2O_5 (although there is some evidence for phase separation above about 80 mol% V_2O_5). The glasses with higher vanadium content are very strongly coloured and contain a large proportion of four-valent vanadium (to some extent dependent on melting conditions). They also show threshold type electronic switching characteristics with a most unusual temperature dependence of threshold voltage V_{th} 1). The latter parameter falls off linearly with increasing temperature, extrapolating to a zero value at 68°C., thus immediately suggesting that there must be some relationship between this switching and the metal-insulator transition in crystalline VO_2. The existence of such a relationship appears to receive some confirmation from the observation of a change in thermal expansion coefficient of the bulk glass at 68°C.

This threshold switching effect has been observed with bulk glasses, including glasses put down by thick-film techniques 2), but can also be obtained in thin film vapour-deposited devices. Its particular interest is that, unlike with other glass switches, at a given temperature an extremely stable value of V_{th} is obtained, which shows no sign of drift or degradation over at least 10^9 switching cycles. This in turn suggests applications in the field of temperature control.

The constancy of V_{th} does appear to suggest it is locked on to some invariant physical transformation. However, the simple picture of a VO_2-like crystalline transition taking place within the switch is not entirely satisfactory. First the glasses, from X-ray diffraction data, are amorphous to at least the 100Å crystallite scale; then, at low fields, current:temperature plots show only a slow upward curvature with no indication whatsoever of any kink or transition at 68°C. Furthermore additions of a number of oxides which significantly alter the 68° transition temperature of crystalline VO_2 have no effect at all on the switching behaviour of the glass, while additions of TiO_2 (which slightly lowers the VO_2 transition temperature) appreciably raise the extrapolated zero V_{th} of the switches. Finally V_{th} shows an appreciable pressure coefficient, decreasing with increasing hydrostatic pressure, while the transition in VO_2 shows a smaller pressure effect of the opposite sign.

The full paper will discuss the preparation and electrical characteristics of the glass switches, and their applications to temperature and pressure monitoring and control.

References

1) C.F. Drake and M. Regan, Materials Research Bulletin, Dec. 1972.

2) Private communication, Pilkington Brothers Research and Development Laboratories, Latham, England.