LUCAS SYALONS: COMPOSITION, STRUCTURE, PROPERTIES AND USES

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1. INTRODUCTION

The successful development of a pressureless sintered material with properties, either as good as or superior to those of Hot Pressed Silicon Nitride (HPSN), has been the main objective of programmes at the Lucas Research Centre since 1972. Following the early pioneering work by Jack and co-workers at the University of Newcastle (1), investigations were started at LRC to prepare strong materials based on a matrix of expanded $\beta$'Si$_3$N$_4$. Identification of the correct composition of the expanded $\beta$' phase, first reported at "Special Ceramics 6" at Stoke-on-Trent in July 1974 (2), allowed a greater understanding of the control of the non-$\beta$' phases. It also allowed better control of the properties of predominantly $\beta$' materials (3,4). Structural studies using transmission electron microscopy at the University of Warwick (4) has allowed a programme of material optimisation to proceed. The use of yttrium oxide as a liquid phase sintering aid has led not only to the development of strong materials but also strong materials which are capable of retaining strength at temperatures up to 1300°C.

The facility that pressureless sintering offers has been demonstrated in that powders have not only been isopressed but, die pressed, extruded, slip cast, and injection moulded (Fig. 1). These shaping routes, followed by sintering, have led to strong materials, as strong as those proposed by isopressing.

The correct composition has been emphasised in a number of publications (3-6). Variations from the ideal result from lack of control in preparation or the use of reactive constituents which do not survive the effect of binders, the shaping environment, or

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Aluminium nitride was found in particular to be a constituent which was a source of problems. Successive batches varied widely in oxygen content, and often contained an unacceptably high level of free aluminium. It was found that the polytype phases of AlN represented an improved unreacted starting constituent. Work in this area has been successfully protected (7). The use of the AlN polytypes in a starting powder leads to characteristic chemical balances and structures which are associated with the optimum properties developed. The use of polytype as a starting constituent is thus easy to detect. Lucas SYALON ceramic materials are therefore combinations of a high $\alpha$-Si$_3$N$_4$ powder, a polytype, and a glass forming metal oxide, currently yttria. Having developed these materials an intensive effort has been mounted over the past four years to exploit them. Many engineering environments have been investigated. A summary of some of these environments is presented as an indication of the possible markets which may develop.