obtained by differentiation of a_T and c_T with respect to temperature are

$$\alpha_a = (29.80 \times 10^{-6}) + (5.91 \times 10^{-8})T \qquad (3)$$

$$\alpha_c = -(14.70 \times 10^{-6}) + (3.67 \times 10^{-10})T^2 \qquad (4)$$

where α and T are expressed in K^{-1} and K respectively. The error in α is estimated to be less than 2.5% per 10 K. The present results (Equations 3 and 4) suggest that α_a varies linearly with temperature and α_c varies non-linearly with temperature. The rate of variation of α_c with temperature is much faster than that of α_a with temperature. This is because the slow variation of α_a with temperature maintains the crystal structure. The variation of α_a and α_c with temperature are presented in Table I. The thermal expansion data of α_c obtained in this work by X-ray diffraction shows anomalous behaviour at higher temperatures (above 390 K). The anomalous behaviour of α_c may be attributed to point defects in crystals.

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Consolidation of Si_3N_4 by shock compression

Silicon nitride (Si_3N_4) has been considered a prime candidate for high temperature engineering materials. So far, the materials have been fabricated with densification aids. The strength of sintered materials at high temperature was lessened due to the softening of intergranular phases containing densification aids. The consolidation of Si_3N_4 without a densification aid has been tried by hot isostatic pressing (HIP) [1], high pressure hot pressing (HPHP) [2, 3] and heating under high nitrogen pressures [4].

The present note reports the results of attempts to consolidate Si_3N_4 by shock compression without a densification aid.

Two kinds of Si_3N_4 powders were used as starting materials, made by AME* and GTE†. Both powders did not densify by hot pressing at 1750° C for 1 h under a pressure of 15 MN m^{-2} without a densification aid. The powder was compacted in a stainless steel capsule at 800 MN m^{-2} to form a disc 4 mm thick and 12 mm in diameter giving a density of about 2.04 g cm^{-3}. The disc was shock-compressed by an explosive plane-wave generator, sometimes called a "mousetrap". The details of the shock experiment are reported elsewhere [5]. The impact pressure induced in

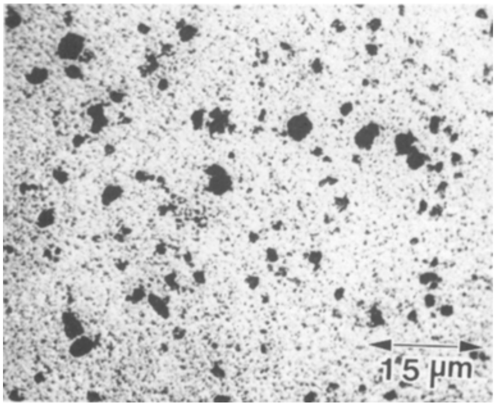

Figure 1 Optical micrograph of polished surface of shock compressed Si_3N_4.

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*Advanced Materials Eng., England, high purity grade, α content = 71%.
†GTE Sylvania, USA, SN-502, α content = 91%.

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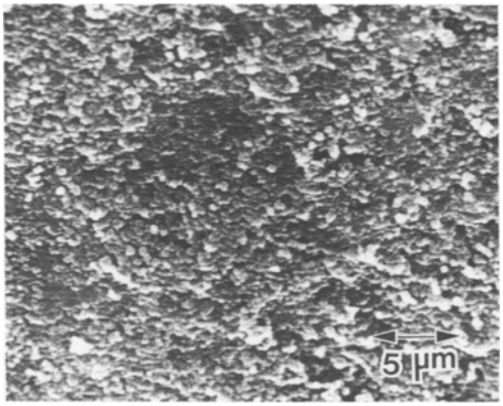

Figure 2 Scanning electron micrograph of fractured surface of shock compressed Si_3N_4.

the capsule was estimated to be 40 GN m^{-2}. The duration of impact was calculated as 2.3 μsec.

The AME powder consolidated to a density of ~ 2.95 g cm^{-3} (92% of the theoretical value) by shock compression. A few cracks were observed in the compact. The polished surface is shown in Fig. 1. Black spots represent residual pores. The fractured surface is shown in Fig. 2. The figure shows that the grains in the compact are very small $< 0.5\,\mu m$. The Vickers microhardness was found to be 1900 kg mm^{-2} under a 100 g load which was greater than the value of hot pressed Si_3N_4 with La_2O_3 of 1500 to 1700 kg mm^{-2}. Prochazka and Rocco [2] measured Knoop microhardness of HPHP Si_3N_4 under a 200 g load. They reported that the microhardness of high density (> 3.00 g cm^{-3}) Si_3N_4 was in the range, 1800 to 3080 kg mm^{-2}. The result suggests that fairly strong bonding was achieved by shock compression of Si_3N_4.

The GTE powder also consolidated to $> 90\%$ of theoretical, but the compact was severely cracked.

The starting powders were mostly composed of α-Si_3N_4. X-ray diffraction of the powdered compacts revealed that most of the α-Si_3N_4 transformed to β-Si_3N_4. The α content after shock compression was 0% in AME and 13% in GTE powder. A small amount of Si was also detected in the powder, which shows that thermal decomposition of Si_3N_4 took place during shock compression. The transformation of α- to β-Si_3N_4 was commonly observed during hot pressing Si_3N_4 with the presence of a liquid phase containing densification aid [6] (solution–precipitation mechanism) [7]. The transformation was also observed during sintering by HIP [1] or HPHP [2, 3] without the presence of a liquid phase. The present work showed that transformation was very fast under shock compression.

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