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HIGH TEMPERATURE NANOINDENTATION TESTING OF AMORPHOUS SILICON CARBONITRIDE THIN FILMS

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The mechanical properties of amorphous silicon carbonitride (SiC_xN_y) films with various nitrogen content (y = 0-40 at.%) were investigated in-situ at elevated temperatures up to 650 °C in inert atmosphere. The hardness and elastic modulus were evaluated using depth sensing nanoindentation with cubic boron nitride Berkovich indenter. Both the sample and indenter were separately heated during the experiments to temperatures 300, 500 and 650 °C. Short duration high temperature creep (1200 s) of the films was also investigated. The results revealed that the room temperature hardness and elastic modulus decline with the increase of the nitrogen content. Furthermore, the hardness of both SiC and SiCN films with lower nitrogen concentration at 300 °C drops to approx. 77% of the corresponding room temperature value, while it reduces to 69 % for the SiCN film with the 40 at.% of nitrogen. Further increase of temperature is accompanied with minor reduction in hardness except for the SiCN film with high nitrogen content, where the hardness decreases at a much faster rate. Upon heating up to 500 °C, the elastic modulus decreases, while it increases at 650 °C due to more pronounced effect of short range ordering. The steady state creep rate increases at elevated temperatures and SiC exhibits slower rates compared to the SiCN films. Analysis of experimental indentation data suggests a theoretical limit of hardness to elastic modulus ratio of 0.143.