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Silicon nitride nanowires toughened boron nitride ceramic composite

Bin Li, Yuanyi Zheng, Duan Li, Xuejin Yang, Shitao Gao and **Yubo Hou**
National University of Defense Technology, PR China

Wave-transparent antenna window for hypersonic aircrafts requires the material to possess sufficient mechanical strength and structural integrity to withstand the aerodynamic force as well as rain and particle erosion, and should exhibit excellent dielectric properties, i.e. low and thermally stable dielectric constant and loss tangent, to transmit microwave signals at high temperatures. As the amost promising candidate of the high temperature wave-transparent materials, nitride ceramics, including boron nitride and silicon nitride, possess excellent high-temperature mechanical properties, superior heat proof ability and fair enough shock resistance. However, as ceramic material, the inherent brittleness acts as an obstacle for its further application in the extreme environment. Therefore, an excellent reinforcement for the wave-transparent composite is required. Silica fiber is the commonest wave-transparent reinforcement and widely used in the last decades, however, its long-time use temperature is blow 1000 °C. Silicon nitride nanowire with high modulus, high strength, low dielectric parameters, and stability at high temperatures, is supposed to be a potential reinforcement to meet the hypersonic flying environment. In this study, silicon nitride nanowires were synthesized by a Vapor-Solid reaction method, and the growth mechanism, the surface element composition of silicon nitride nanowires were investigated. The as-received silicon nitride nanowires at 1500°C exhibit a diameter about 200nm, a length about several millimeters and a relative high yield. The low dielectric boron nitride ceramic matrix composites toughened by silicon nitride nanowires were then fabricated. The composites exhibit good mechanical properties and excellent dielectric properties, with the flexural strength of 120 MPa, the fracture toughness of about 5.5 MPa•m1/2, the dielectric constant of 3.1 and the loss tangent of 0.002. The toughening mechanism includes crack deflection, nanowires pull-out, nanowires bridged and nanowires breakage in the composites.

libin@nudt.edu.cn