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STRUCTURAL OPTIMIZATION OF NANO-POROUS INSULATION MATERIALS

Abstract

Nano-porous insulation material with ultra low thermal conductivity at high temperatures is demanded for future space vehicles, but its serving temperature is limited due to sintering of the nano-particles, e.g. up to 800Deg C for SiO2. Aerogel as a candidate material was studied in order to promote its serving temperature and improve its thermal conductivity. Besides to one's expectation of micropores and nanosized particles, N2 sorption measurement of the aerogel materials showed that the volume fraction of macropores with diameter larger than 50nm exceeded 65% for all 9 samples produced by sol-gel method. The results implied that thermal insulation performance of the aerogel materials would not be as good as one expected based on a consideration of complete suppression of the gas molecular diffusion. Thermal conduction calculation was carried out based on the intersecting spheres model, which showed that thermal conductivity remarkably increases with rising pore size and/or the volume fraction of the macropores. This viewpoint was confirmed by several model samples, which contained intentionally introduced macropores formed by burning carbon fiber or carbon black particles imbedded into the aerogel matrix. With above mentioned key point in mind, an insulation material with solid backbone particle of 10nm which is much bigger than tradional matrials was prepared. Thermal resistance test showed the sample survived 1050Deg C for 1h with a tiny shrinkage of 1.5% in thickness. The thermal conductivity was measured by a laboratory developed instrument, showing a value of 0.02W/mK at room temperature and 0.05W/mK at 1000Deg C. The sample with thickness of 30mm was tested by quartz lamp heater at 1100Deg C for 25 minutes and the cold surface temperature is 72Deg Cwhich showed both good thermal stability and excellent insulating performance.