A METHODOLOGY BASED ON IN SITU CRACK PROPAGATION AND MODELING FOR DESIGNING CERAMIC COMPOSITES FOR USE AT HIGH TEMPERATURES

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Fiber-reinforced ceramic matrix composites (CMCs), by incorporating fibers in ceramic matrices, not only exploit their attractive high-temperature strength but also enhance their toughness thereby rendering these attractive for many applications. Some of these applications require an understanding of the interrelationship among processing, fiber-matrix interface and mechanical properties both at room and elevated temperatures. In addition, these applications require an understanding of the crack propagation and fracture behaviors in CMCs for assessing their performance, life prediction and for designing superior CMCs with even higher temperature capability. Processing of CMC is typically done by chemical vapor infiltration (CVI), filament winding and hot-pressing, and polymer infiltration and pyrolysis (PIP) techniques. Most of these approaches do not lead to full-density unless external pressure is applied. A novel approach of melt-infiltration (MI) process is a promising technique for fabricating fully dense and net-shape SiC fiber-reinforced SiC composites. The processing of such CMCs by MI was pioneered, invented and developed for making fully dense, net- and complex-shape CMCs in mid 1980's, which is being commercialized for applications in jet engines. In order to explore mechanical properties of CMCs, a novel in situ technique based on video imaging is used to directly observe and measure crack growth and fracture behaviors in CMCs between 25°-1400°C under monotonic and fatigue loads. The results of the crack growth thus obtained are used to analyze fracture resistance behavior, and theoretical analyses are done to develop models to predict the crack growth and fracture resistance behaviors. Bridging stress functions are also obtained from the analytical models over a range of temperatures, which are then used in designing CMC with superior elevated temperature mechanical properties. The models developed are used to identify the roles of the fiber, matrix, and interface properties in obtaining superior properties for use at even much high temperatures. These results on SiC_f-reinforced CMCs will be presented and discussed.