EFFECT OF MATRIX POROSITY AND PREPREG-TACK ON MECHANICAL PROPERTIES AND PROCESSING OF OXIDE CERAMIC MATRIX COMPOSITES

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Most oxide ceramic matrix composites (OMC) attain their damage tolerant fracture behavior according to the weak matrix composite concept, whereas a designed matrix porosity ensures mechanical decoupling of the fibers and energy dissipating mechanisms such as crack deflection. For the lay-ups of prepregs, the adherence of the layers is especially important to avoid delaminations or misalignments of the fabric layers. Thus, microstructural requirements together with the processing behavior are essential in order to develop new slurry systems for OMC prepregs. In this contribution we present results on the effect of the matrix porosity on mechanical properties as well as a new measuring method to assess the prepreg tack of continuous fiber reinforced OMC.

The used prepregs were made from a slurry containing coarse and fine grained alumina as well as zirconia. Desized fabrics of Nextel^{TM}-610 were infiltrated with the slurry and subsequently conditioned in a climate chamber before they were dried and fired. For the study on the matrix porosity, prepared samples were infiltrated up to seven times with zirconium-n-butoxide (ZrO_2-precursor) in butanol. After each infiltration step, the samples were heat treated at 950°C in air to pyrolyze the precursor and to remove carbon residues. The last heat treatment was carried out at 1225 °C resulting in a crystallization of the precursor. The infiltrated samples were compared with uninfiltrated samples. All samples were investigated on their open porosity, their microstructure, flexural and interlaminar sheer strengths, respectively. For the investigation of the lamination behavior, three different slurries, with graphite particles, acting as a pore former, were used. First, the rheological behavior of the three slurries was investigated with a newly developed roll laminator. With roll laminator different tacking behavior of a prepreg stacks in process-oriented conditions, i.e. during the application and removal of compression force, can be studied. This provided qualitative information on the squeeze flow of the slurry associated with a high compaction level and its ability to maintain this imposed level of compaction with no rebounding.

No effect of the heat treatment cycles was determined within the three-point-bending tests. Even so, a damage-tolerant behavior was present until 37 % matrix porosity before the bending strength starts to decrease from 399 MPa to 298 MPa. Beginning at a matrix porosity of 34 %, a brittle failure with bending strengths of 269 MPa to 250 MPa was observed. The Young's modulus increased with a decreasing porosity ranging from 96 GPa and 46 % matrix porosity to 153 GPa with a porosity of 30 %. A denser matrix resulted in a higher interlaminar shear strength. In this case, the heat treatment caused an increase from 11.8 MPa to 13.9 MPa. With the infiltration cycles, the shear strength increased until a maximum of 25.5 MPa at a matrix porosity of 35 % was reached, before it again decreased. The evaluation of rheological slurry properties alone was insufficient to assess their suitability for the lay-up process. However, the novel measuring method corresponded well with the fabrication of full-scale OMC plates. Hence, the novel method provides a more straight-forward approach for the evaluation of prepreg systems, reducing the expense of material and time for new slurry systems.