FABRICATION OF CERAMIC MATRIX COMPOSITES BY SOL-GEL PROCESS

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Sol-gel Infiltration – description

Sol-Gel process of a fabrication of Ceramic Matrix Composites involves preparation of the matrix from a liquid colloidal suspension of fineceramic particles (**sol**), which soaks a preform and then transforms to solid (**gel**).

Colloidal suspension is formed as a result of chemical reaction when very small particles with radii up to 100 nm (nanoparticles) precipitate within a liquid (water or organic solvent).

Liquid sols have a low viscosity therefore they easily infiltrate into the preform.
At elevated temperatures sols containing organometallic compounds (e.g. alkoxides) undergo cross-linking (polymerization) by either the polycondensation or hydrolysis mechanism.
Polymerization converts sol into gel – a polymer structure containing liquid. Gels may be transformed into Ceramics at relatively low temperature, which reduces the probability of the reinforcing fiber damage.
Alumina matrix ceramic composites may be prepared from alumina gel, which forms in hydrolysis (decomposition as a result of reaction with water) of aluminum alkooxides.
Since the amount of ceramic in gels is relatively low they undergo significant shrinkage after drying. The densification of the ceramic matrix is commonly increased by repeating the infiltration-drying cycle several times until the desired density is achieved. Further increase of the volumetric yield of ceramic of a Sol-Gel may be achieved by an addition of ceramic particles. The added ceramic particles also decrease a formation of cracks in the drying stage.

Sol-gel Infiltration process

- Fabrication of the repreg. The reinforcing fibrous material is immersed into the sol. The sol wicks into the porous structure of the reinforcing phase. Vacuum/pressure may be applied to assist the infiltration process.

- Lay-up. The prepreg is shaped by a tooling (mold).
- Gellation and drying. The sol is heated to 150°C (302°F). It is converted into gel, which is then dried at a temperature up to 400°C (752°F). Water, alcohol and organic volatile components are removed from the material.
- Repeated re-infiltration and gelation. The sol infiltration-gelation cycle is repeated several times until the desired densification is achieved.
- Firing. The ceramic matrix is consolidated (sintered) at the firing temperature.

Advantages and disadvantages of Sol-gel Infiltration

Advantages of Sol-Gel Infiltration:

- less reinforcing fiber damage due to low processing temperature;
- Controllable matrix composition;
- Low equipment cost;
- Low machining cost due to near-net-shape fabrication;
- Large and complex parts may be fabricated.
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Disadvantages of Sol-Gel Infiltration:

- Possible matrix cracking because of large shrinkage;
- Multiple infiltration-gelatin cycles are required in order to increase the ceramic yield;
- Low mechanical properties;
- High cost of sols.

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