REINFORCING FIBERS FOR CERAMIC COMPOSITES

- **Fiber architecture**
- **Fiber materials**

Fiber architecture

Different forms of reinforcing phase may be used in Ceramic Matrix Composites: particles, whiskers, platelets, continuous or chopped fibers.

Fibrous reinforcing phase may be arranged in different structures (unidirectional, 2D, 3D):

- **Fiber bundles (tows)**. Tows are used for reinforcing in one direction. According to the number of thousands of filaments (ends) fiber bundles are denoted: 1K (one thousand ends), 3K, 6K, 12K.
- **Tapes (unidirectional fabrics)**. Tapes are the fabrics characterized by a greater number of warp yarns (yarns running in the tape roll direction) as compared to the number of picks (fill yarns running crosswise to the tape roll direction).
- **Two-dimensional structures**. Woven structure of bidirectional fabrics has similar numbers of warp yarns and picks.
- **Three-dimensional structures**. Yarns running in three different directions are utilized in 3D fabrics. 3D composites are produced from such fabric.
- **Braided architecture**. This type of 3D structure is used for fabrication 3D net-shape composites.

Fiber materials

Different ceramic materials (silicon carbide, carbon, alumina, silica) provide different combination of the fiber properties: strength,modulus of elasticity, flexibility, creep resistance, chemical stability and oxidation resistance.
Silicon carbide (SiC) and carbon are the most popular fibers materials.

Filaments from organosilicon precursors are used for fabrication of silicon carbide fibers. SiC is formed during the precursor curing (cross-linking) followed by heating in nitrogen atmosphere to a temperature of about 2200°F(~1200°C).

The most popular trade marks of SiC fibers: Hi-Nicalon, Nicalon S, Sylramic, Tyranno.

The properties of SiC fibers:

- Modulus of elasticity (stiffness)is up to 61 Msi (420 GPa);
- |Tensile strength is 493 ksi (3.4 GPa);
- Thermal stability is up to 2642°F (1450°C);
- Filament diameter is 10-15 µm.

Carbon fibers are fabricated from organic precursor filaments. At the first stage they are carbonized in nitrogen at a temperature of about 2200 °F (~1200°C) and then graphitized at about 4500°F (~2500°C).

The most popular trade marks of carbon fibers: BP Amoco, Conoco, Grafil, Granoc, Toho, Toray, Zoltek.

The properties of carbon fibers:

- Modulus of elasticity (stiffness): is up to 133 Msi (920 GPa);
- Tensile strength is up to 1000 ksi (6.9 GPa);
- Density is 114 lb/ft³ (1800 kg/m³);
- High chemical inertness;
- Filament diameter is 5-15 µm.

Low oxidation resistance is the main drawback of carbon fibers, which oxidize when exposed in air at temperatures exceeding 932°F (500°C).

Alumina fibers, which are the most popular oxide fibers, are manufactured from an organic alumina precursor. The precursor transforms into alumina after heating to 1472°F (800°C). Mullite fibers are fabricated from a mixture of alumina precursor with an organosilicon.

The properties of alumina fibers:

- Modulus of elasticity (stiffness) is up to 54 Msi (373 GPa);
- Tensile strength is 479 ksi (3.3 GPa);
- Density is about 256 lb/ft³ (4100 kg/m³);
- Filament diameter is 5-15 µm.

The main disadvantages of alumina fibers are relatively low creep resistance caused by grain growth at high temperatures and relatively high density.

Source : http://www.substech.com/dokuwiki/doku.php?id=reinforcing_fibers_for_ceramic_composites