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THE OBSERVATION OF FIBER MICROSTRUCTURES IN BIOMORPHIC SiC

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Advanced silicon carbide (SiC) ceramics are leading candidate materials for many applications in the aeronautics, energy, electronics, nuclear, and transportation industries. A recently developed fabrication technique [1-3] allows for the fabrication of siliconiced SiC - biomorphic SiC from natural wood precursors. The main advantages of the technique are: low cost, high strength, and near net-shape fabrication. The diversity of wood microstructures offers a large variety of options in terms of material selections. The objective of this research is to show a new sample preparation technique for the observation of fiber microstructure and to understand the infiltration mechanism of siliconiced biomorphic SiC.

Selected wood samples (red eucalyptus, pine and beech) were pyrolized/carbonized at 1000°C in an argon atmosphere. These carbonized wood samples were then infiltrated with a reduced amount of molten silicon (1/5 moles of Si for 1 mol of C) at 1550ºC in vacuum for 30 minutes, to allow only partial reaction until all silicon was consumed. The remaining carbon (without reacted with Si) was burned in a furnace with oxygen at 1000 ºC for 6 hours. The sample was then cleaned with compressed air, and characterized in a SEM. This technique results in a complete conversion of carbon to SiC, enabling a structural study without the use of the TEM. Other physical/mechanical properties were also measured to study the relationship between the mechanical property and microstructure.

SEM images, as shown in Figs. 1 and 2, show the typical morphology of pyrolized carbon and siliconized biomorphic SiC of beech wood, respectively. In addition to the EDS spectra shown in both figures, the narrow channels and the thick fibers indicate the infiltration of Si into the wood structure and formed biomorphic SiC. Figures 3 through 6 reveal more morphological observation of biomorphic SiC from a variety of woods with different direction/orientation, i.e., parallel (axial) and perpendicular (radial) to the grow direction of the former wood precursor. In general, the microstructure of pyrolized carbon is very much like the microstructure of the precursor wood, and it consists of fairly paralleled channels as well as some radial channels. The fibrous microstructure of the wood is reproduced in the SiC because the reaction is channeled by the porous carbon preform microstructure. The connection between precursors wood channels produces an interconnected SiC structure. In figures 4 and 6 the formation of SiC with cross-bedded fiber character can be seen and appears as a continuous fiber. Apparently, the newly formed biomorphic SiC is highly anisotropic and interconnected in both parallel (axial) and perpendicular (radial) directions. Fig. 7 demonstrates the improved crashing strength using the biomorphic SiC. In short, the characteristic of highly connected fibrous microstructure of biomorphic SiC, the consequence of being mimetic to natural structures, offers a new type of low density ceramic material with improved mechanical properties.

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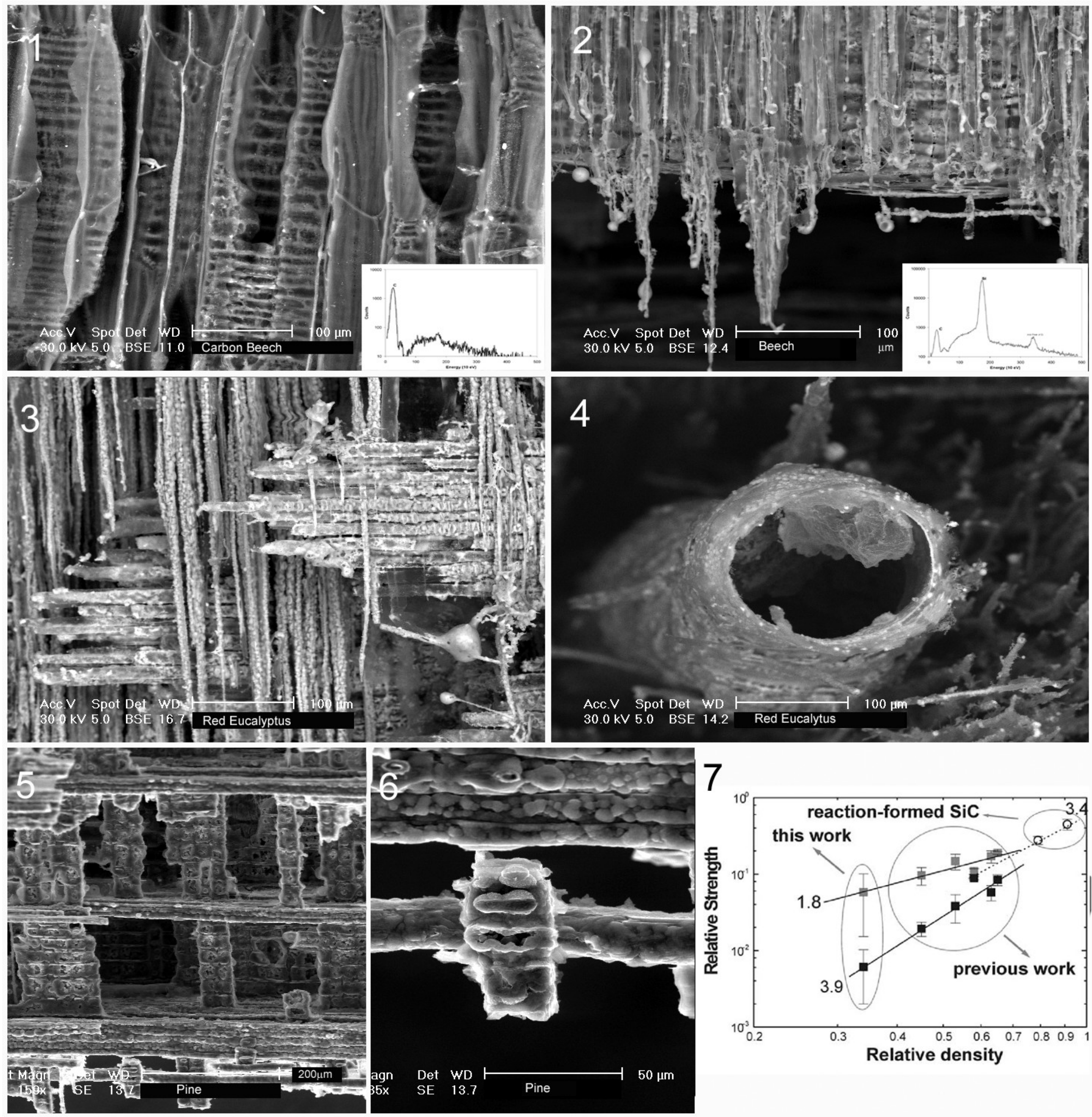

Fig. 1. SEM image and EDS of pyrolized/carbonized beech wood showing the fibrous structure.

Fig. 2. SEM image and EDS of beech wood after Si infiltration of Si and forming SiC.

Fig. 3. SEM images of red eucalyptus wood cut parallel to the former wood precursor.

Fig. 4. SEM images of red eucalyptus wood cut perpendicular to the former wood precursor.

Fig. 5. SEM images of pine wood revealing the details of interconnected structure.

Fig. 6. SEM images close-up view of pine wood showing the detail of the fibrous microstructure.

Fig. 7. Comparison of relative strength vs. the relative density of SiC from different sources.