Oxide scale morphologies in the multi-component system Si-(B)-C-N-(Al) in dry and humid atmospheres

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During the past years, a number of investigations of the high-temperature stability of precursor derived ceramics in the system Si-B-C-N were published. In inert atmospheres, a close connection between chemical composition and thermal stability was found. While boron-free ceramics decomposed at temperatures of 1500°C, the additional incorporation of boron prevented decomposition up to temperatures of 2000°C. However, not only the absolute amount of boron, but also the relative amounts of all elements present as well as the precursor used had an influence [1].

To investigate the high temperature stability in dry oxidizing environments, a number of samples with different compositions in the system Si-(B)-C-N were oxidized up to 100 hours at 1500°C. Distinct differences between boron-free and boron-containing samples were observed. This applied to the oxidation resistance, which in the case of the boron-containing samples resembled that of CVD-SiC and CVD–Si_3N_4 (see Fig. 1), as well as to the structure of the oxide scales. At 1500°C crystalline cristobalite scales formed on Si-C-N materials whereas scales on the Si-B-C-N ceramics remained largely amorphous even after oxidation times of 100 hours [2].

The addition of aluminum to the system further improved the scale quality with respect to cracking and spallation, as well as bubble formation, which were problems in the Al-free systems mainly after long oxidation times at high temperatures (Fig. 2).

First investigations of the influence of humidity gave hints on an increase in the oxidation rate under these conditions. However, investigations of the oxidation behavior of CVD-SiC in humid atmospheres carried out by Opila [3] showed, that the increase in the oxidation rate at high temperatures could partly be due to alkaline impurities, which were dissolved from the Al_2O_3 reaction tube and were incorporated into the oxide scales. To avoid contamination during high-temperature experiments, all experiments presented in this paper were carried out in a mirror furnace with SiO_2 reaction tube (Fig. 3). In this furnace, the radiation of six 1kW halogen lamps was focused on the sample. Dependent on the adsorption properties of the materials used, temperatures of 1700°C could be reached within less than a minute while the environment remained relatively cold.

Results of systematic investigations of the influence of the water content on the oxidation behavior of precursor derived ceramics comparing SiCN, SiBCN, and SiBCNAl materials will be reported and compared with results obtained under dry conditions.

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FIGURES

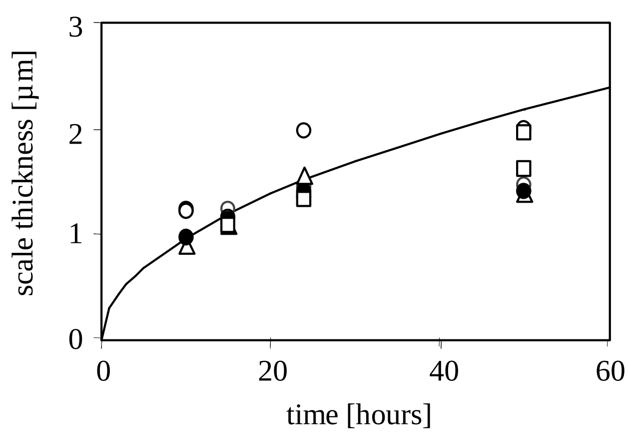

Figure 1: Comparison of the scale growth on different precursor derived Si-B-C-N ceramics (squares, circles, and triangles) and CVD-SiC (solid line) after oxidation at 1500°C in dry oxygen. Data for CVD-SiC from [3].

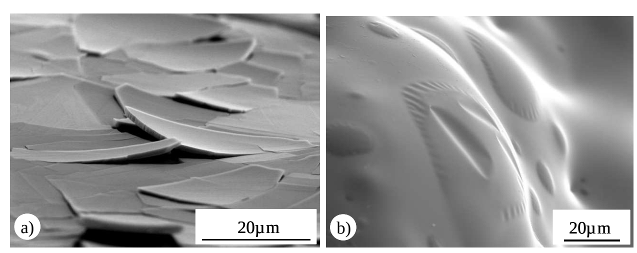

Figure 2: Influence of the sample composition on the quality of the oxide scale after oxidation in dry oxygen for 15 hours at 1500°C. a) Cracking and spallation on SiBCN, b) pore closure by oxide scale on SiBCNAl.

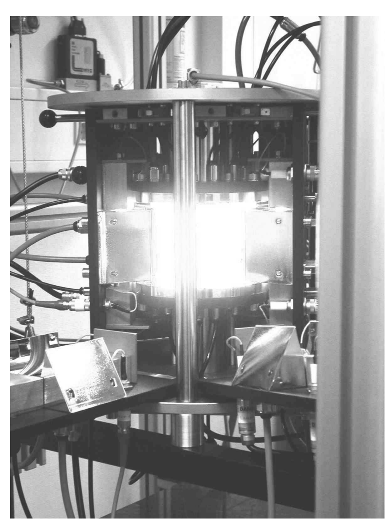

Figure 3: Mirror furnace.