SODIUM COMPATIBILITY OF CERAMICS


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1. INTRODUCTION

As ceramics recently developed possess an excellent heat-resisting property, they are expected to be used as tribological parts and thermal liner to improve the reliability and thermal efficiency of FBR by elevating its coolant temperature. The authors' objective of the research on ceramics is to make clear the points to be improved on chemical compositions, micro-structure and manufacturing process through the investigation of above existing ceramics on their sodium corrosion mechanisms and to create the advanced ceramics which meet sodium environment.

2. TEST METHOD

As the first step of research, sintered ceramics recently catalogued by several companies including C, N, S and K in Japan were tested in sodium. Single crystals and chemical vapour deposition (CVD) ceramics were also tested as reference materials. Generally speaking, sintered ceramics possess grain boundaries and impurities or additives, on the contrary, CVD ceramics possess grain boundaries without impurities and additives, and single crystals do not have any grain boundaries and impurities or additives. As a fundamental approach to clarify sodium corrosion mechanisms, these three kinds of ceramics were mutually compared in the view point of existence of grain boundaries, impurities and additives.

Figure 1 shows the overall research process to create advanced ceramics for usage in fast reactors. Tested ceramics are shown in Table 1.

These ceramics were exposed to 550 and 650°C sodium for 1000 and 4000 hours at an oxygen level of 1 ppm.

As the second step of research, the advanced ceramics were trially manufactured by C based on the countermeasures to improve the resistance to sodium corrosion of the existing ceramics and exposed to 550 and 650°C sodium for 1000 hours to clarify the effect of improvement on corrosion resistance.
3. TEST RESULTS OF EXISTING CERAMICS

The weight changes due to sodium exposure are shown in Fig.2 and Fig.3. Data for \( \text{Al}_2\text{O}_3 \) of 99 - 99.9% purity are plotted in Fig.3. Alumina of lower than 99% purity cracked and fell its grain by grain boundary attack. All \( \text{ZrO}_2 \) samples increased their weight. In contrast, almost all the other ceramics lost their weight and indicated higher corrosion rate with longer exposure time and higher sodium temperature. Especially, the weight losses of sintered SiC, \( \text{Si}_3\text{N}_4 \), SiAlON and TiC showed the significant time and temperature dependency. Spinelns (\( \text{MgAl}_2\text{O}_4 \) and \( \text{Y}_3\text{Al}_5\text{O}_{12} \)), \( \text{Y}_2\text{O}_3 \), AlN and AlON showed the most excellent corrosion resistance among sintered ceramics and no evidence of grain boundary attack by SEM observation. Single crystals and CVD ceramics showed superior corrosion resistance to sintered ceramics. However, CVD BN as well as sintered BN showed the most significant corrosion among all tested ceramics. Single crystal of TiC showed the highest weight loss among single crystals.

In sintered ceramics, a colour changed layer was formed near sodium exposed surface, whose depth depended on exposure time, as shown in Table 2.