P04

宇宙実験用グラファイト製坩堝の封入技術の開発

Development of encapsulation technology for graphite crucibles for space experiments

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1. Introduction

In recent years, microgravity environments have been used in the development of high-quality semiconductors and high-performance composites with uniform compositions, since it is easy to mix materials that would otherwise be hindered by differences in specific gravity on the ground, and it is expected to be applied to the production of materials on the ground. However, the graphite crucibles required for such material experiments cannot be hermetically sealed and are triple-sealed using quartz glass or tantalum capsules. If graphite crucibles can be welded, the three-layer encapsulation can be reduced by one, which will accelerate the development of new materials. In this study, focusing on the electrical conductivity of graphite and the Al-B-C ternary state diagram1) , we performed arc welding using graphite as the base metal, boron carbide, and Aluminum, and arc welding was performed to measure the possibility of welding and the tensile strength of the welded area.

2. Methods

Experiments were conducted in a glove box under an argon gas atmosphere. First, graphite specimens were prepared by cutting two pieces of a smooth plate 5 [mm] thick, which was reduced to a quarter scale of a standard tensile test specimen No. 13, and then cut in half in the center. The specimens were placed so that their end faces faced each other, and granular boron carbide and aluminum were placed on top of the specimens, which were then welded by arc discharge directly above them. A TIG welding machine (RILAND/TIG 200P) was used for arc discharge and a φ1.6 YWCe-2 electrode was used. After welding at an output current of 70 [A] DC with positive polarity, the specimen was turned over and welded again at an output current of 180 [A] DC with positive polarity. The specimens were then subjected to a tensile testing machine to measure tensile strength.

Boron carbide and aluminum prepared under the same conditions were powdered and measured by XRD (Rigaku/Rint-TTRⅢ).

3. Result and Discussion

Figure 1. shows the weld zone of a specimen welded by arc discharge.
From **Figure 1.** , it was confirmed that graphite was welded using boron carbide and aluminum. It was also confirmed that some of the graphite evaporated due to the arc heat and adhered to the surrounding area of the weld.

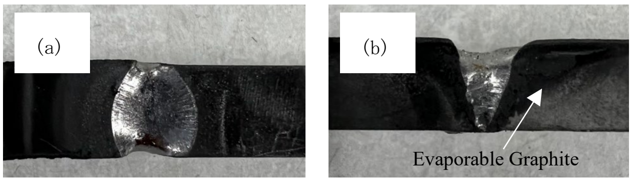

Figure 1. Welded graphite

(a) welded area viewed from above, (b) welded area viewed from the side.

Figure 2. shows the cross sections of the welds. (a) shows the cross section of a weld made using only boron carbide and (b) shows the cross section of a weld made using boron carbide and aluminum. In the cross section of the welded zone welded with only boron carbide, depressions were observed due to the detachment of crystallized graphite grain boundaries when the welded zone was cut by a precision cutting machine. No such depressions were observed in the welded joints welded with boron carbide and aluminum, and compound precipitation was confirmed.

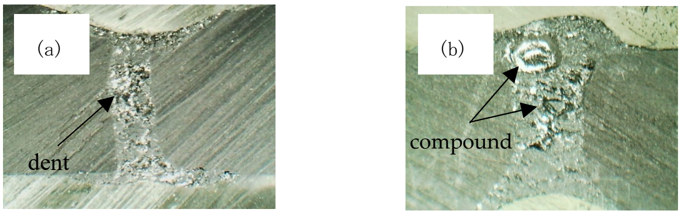

Figure 2. Cross-sectional view of welded area

(a) shows the welding process using only B4C, and (b) shows the welding process using B_4C and Al.

Analysis of the compounds formed in the welded area using XRD confirmed that $B_{13}C_2$ and AlB_{12} were formed in all cases. The welded specimens were then tensile tested and the results are shown in **Table 1.**

Table 1. Tensile test results

B4C:Al mass ratio	Tensile strength [MPa]
Pure B4C	8.313±3.607
12:1	12.14±4.824
9:1	10.39±4.837
7:1	9.423±3.084
6:1	7.815±1.945
3:1	5.024±1.600
Graphite	11.91±5.271

The Graphite in **Table 1**. is the result of tensile testing of pure graphite which is the same shape as the welded specimen to determine the strength of the graphite. From **Table 1.** , it is confirmed that the lower the aluminum content, the greater the tensile strength. The results of XRD analysis also confirmed that the higher the aluminum content, the more compounds such as AlB_{12} are found in the welded zone.

4. Conclusion

Graphite was welded by boron carbide and aluminum by TIG welding.

References

1) A Masahiko Iyoda: Encyclopedia of Carbon . Asakura Shoten(2007)