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Development of pure boron pellet for fusion reactor

Hiroyuki Noto[1], Sadatsugu Takayama[1], Tomoko Kawate[2], Yasuko Kawamoto[1], Motoshi Goto[1], Masaki Osakabe[1]

(a) National Institute for Fusion Science

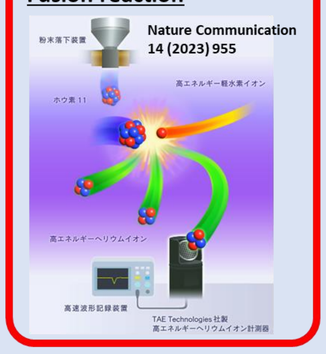
(b) National Institutes for Quantum Science and Technology

ABSTRACT

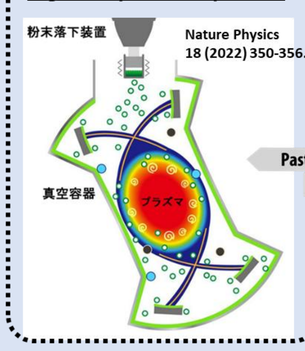
Boron (B) is an attractive element for proton-boron (p-B11) fusion reactions, also attracts attention as an element for inducing high-temperature plasmas and as an operational boronizing element in the deuterium (D)-tritium (T) reaction.. In previous the injection experiment of boron, small cylindrical capsules contained boron powder and powder dropper have been employed. However, in previous injection experiments using small cylindrical capsules, critical issues remained, such as the small amount of injected element and the contamination of impurities from the small cylindrical capsule, and there was also the issue that the powder dropper method could not be used to inject into the core plasma. As the solution of the critical issue, author(s) proposed simple pure boron pellet without small cylinder capsule and powder dropper method, suggested the sintering process of pure B, which showed advantage of processability and withstand pellet injection. In this paper, the production process and the B pellet injections experiments were introduced.

BACKGROUND

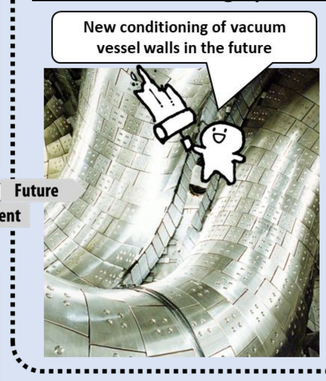
proton-boron (p-b) Fusion reaction

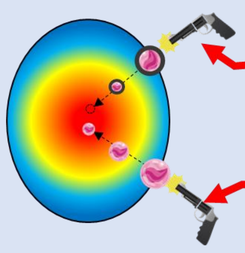


Inducing the high temperature plasma



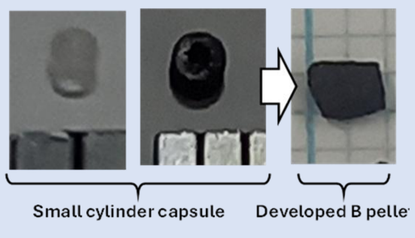
boronization during operation





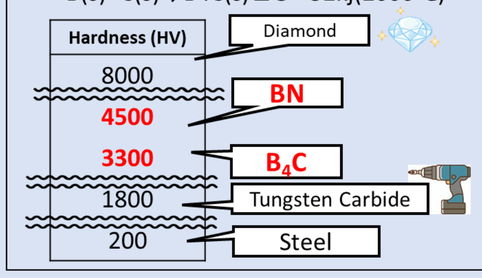
the small amount of injection elements and the contamination of impurities from the small cylindrical capsule

As a solution to this critical issue, the authors proposed a process for sintering pure B without using small cylindrical capsules.



authors speculated that impurity carbon from the high-temperature furnace would bond with the original boron particles on the particle surface.

$B(s)+C(s) \rightarrow B_4C(s)$ $\Delta G=-52kj(2000°C)$



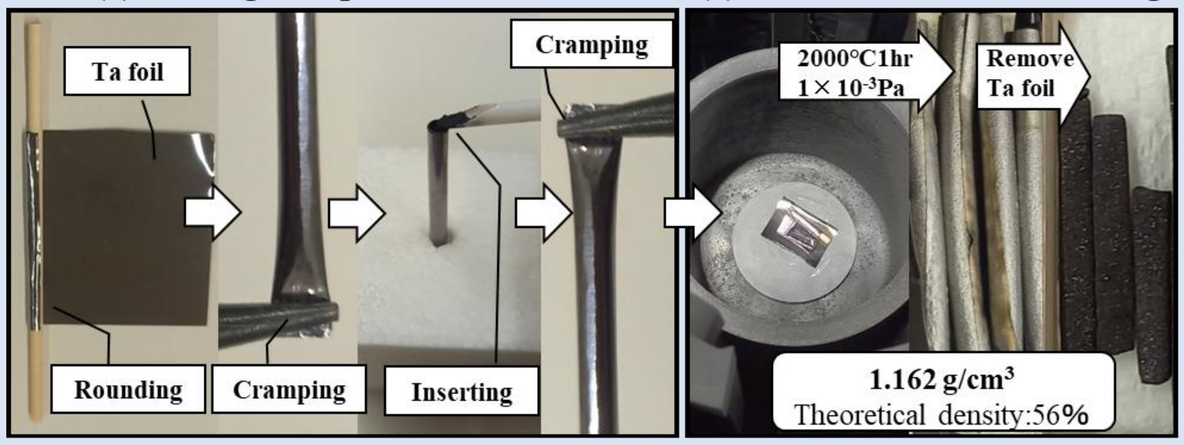
Considering the carbon contamination on the surface of boron particles, the authors developed a sintering method of pure boron using “tantalum (Ta) foil”, which is widely known as the getter effect of impurity carbon.

In this paper, we present a sintering process using tantalum foils without sintering loads and injection experiments using sintered boron pellets.

METHODS

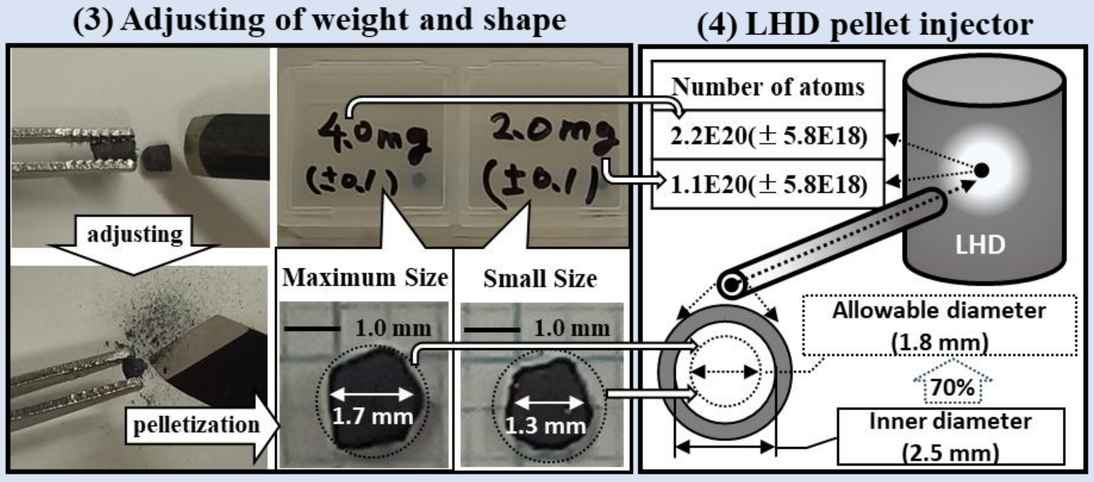
(1) Packing of B powder to Ta foil

(2) Heat treatment for sintering



(3) Adjusting of weight and shape

(4) LHD pellet injector



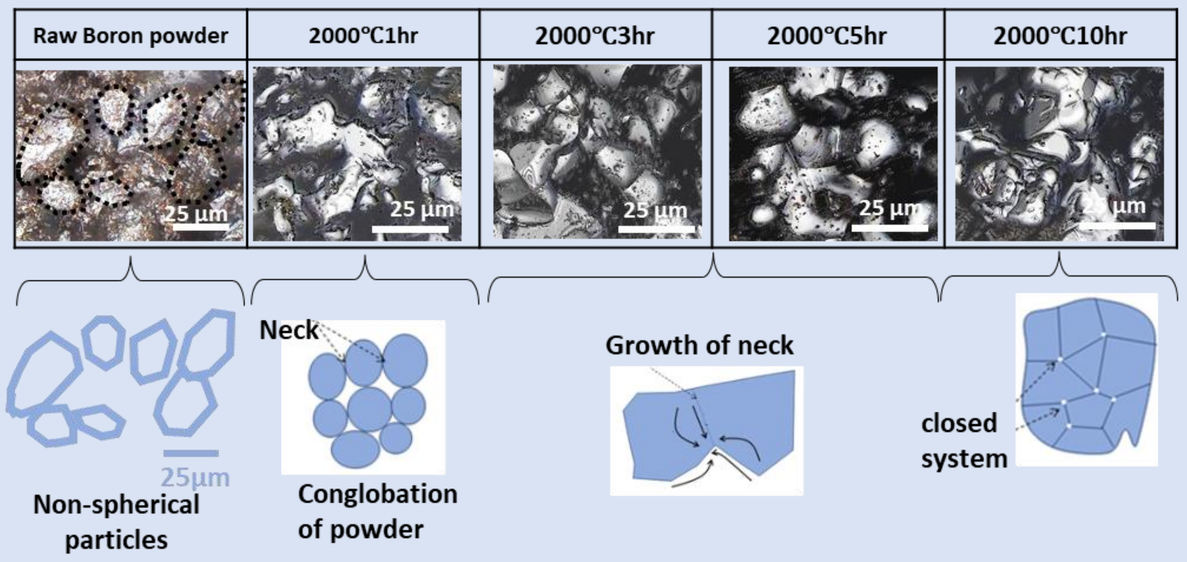
OUTCOME

Table 1 chemical analysis of B pellet

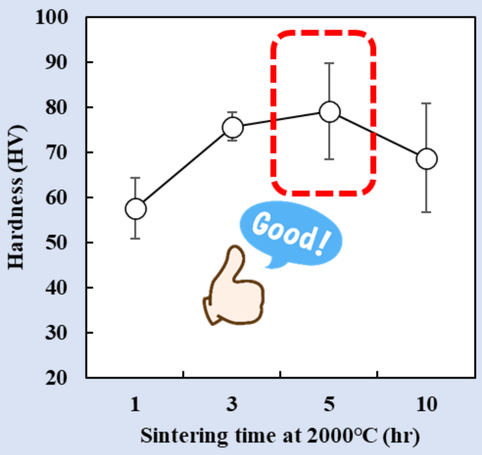
	Tantalum	Carbon
Concentration (Wt%)	0.02	0.64

Ta contamination from the foil was below the lower limit, and despite the use of a graphite furnace for sintering

carbon impurities from the furnace were so low, implying that almost sintered boron was not carbonized.



Raw boron powder of 40μm diameter before sintering was shaped non-spherical particles. After 1 hour at 2000° C, the particles were spheroidized and necked between particles. Then, after 5 h at 2000 ° C, the growth of grain necks was observed, and finally, after 10 h at 2000 ° C, the grains were further sintered with a slightly close system (micropores).



Similar injection experiments using "11B" are planned for the next LHD experimental campaign, and our group hopes to be able to carry out the next experiment using this process. Pure boron is also expected to be used to boronize the walls of operating vacuum vessels, and its use is expected to expand to nuclear fusion experiments around the world.

CONCLUSION

Boron is considered a promising element in proton-boron (p-B11) fusion reactions. Therefore, the fabrication process from raw powder to injection pellet was required. In this starting study, we proposed the fabrication process of simple pure boron pellets without previous small cylinder capsule and powder drop equipment. In this paper, the effect of sintering time on the microstructure was investigated. The main results are as follows:

1.Pure boron has been successfully sintered without applying sintering loads. The sintered boron exhibited the advantage of processability and the strength to withstand pellet injections. Pellets fabricated from pure boron have survived injection for plasma experiments.

2. Considering the effect of sintering time on the microstructure, the growth of necks and slightly close systems (micropores) between boron particles were observed with increasing time to sinter, suggesting the possibility of developing even denser pellets.