

User Protocol for Ultra-high temperature Ceramic (B4C) Ink for Direct-Ink Writing

Catalog No. [921912](#)

Chemicals Needed:

- 3D Printable Ultra-High Temperature Boron Carbide Ink (product **921912**)
- De-Ionized water

Equipment/Consumables Needed:

- Mixer container
- Plastic Spatula
- Balance
- Planetary Mixer
- Syringe (with caps)
- Syringe Nozzle
- Syringe plunger
- Direct-Ink Write (DIW) Printer
- Glass slides
- Oven and Furnace for drying and sintering

Step by Step Procedure for Ink Mixing and Loading into Syringe:

- (1) Place mixer container on balance and tare weight.
- (2) Using the spatula, scoop out desired amount of B4C ink (product 921912) from container into the mixer container on the balance. (For reference, for filling a 30-cc syringe, 46 grams of the B4C ink is sufficient.)
Note. Due to high solids loading, it is possible that the ink is too viscous to scoop out due to evaporation of solvent.
In that case, add 1-2wt.% of de-ionized water to the mass of ink taken in the container and subject it to thick mixing.
Adding more than 2wt.% of de-ionized water lowers viscosity greatly to an extent that it cannot be printed.
- (3) Using a planetary mixer, mix the ink using the following mixing sequence:
 - a. Mix setting @ 2000 rpm for 2 min.
 - b. Defoam setting @ 2200 rpm for 1 min.Repeat this mixing sequence twice. With hand mixing in between.
Note. Mix until a smooth paste is obtained.
- (4) Once thoroughly mixed, the ink can be loaded into a capped syringe for DIW Printing. Using the spatula, scoop the ink from the container and deposit on the side of the syringe.

- (5) Carefully tap the ink from the syringe wall to fill the syringe fully.
- (6) After all ink is loaded into the syringe. Place the syringe into the mixer and use the Defoam setting @ 2200 rpm for 10 seconds to eliminate trapped air bubbles that will cause inconsistencies in printing.
- (7) After plunger is placed into the syringe, ink is ready for printing.

Other Notes for DIW:

- Syringe Nozzle sizes ranging from 400 μm – 800 μm can be used
- Initial pressure for DIW printing ranges from 45-60 psi, depending on nozzle diameter used
- The ink can be directly printed on a glass/graphite substrate greased with Vaseline

Post Processing of DIW printed parts:

- (1) The printed sample is subjected to air drying at room temperature for 48h, followed by 80°C oven dry for 8h.
- (2) Pre-heating of dried parts at 1050 °C for 3 h at 5 °C/min ramp rate in a tube furnace with flowing gas composed of 4 vol% hydrogen and 96 vol% argon.
- (3) The parts are subsequently sintered in a high temperature graphite furnace at 2260–2295 °C for 1 h under gas flow.
- (4) The sintering temperature can be predicted by the following phase diagram.

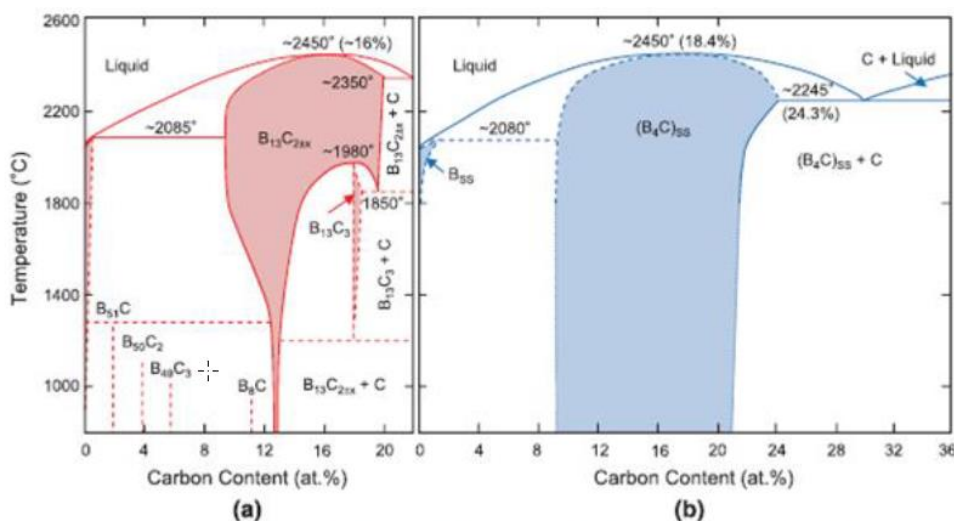


Figure 1: Phase diagram of B_4C (J. Am. Ceram. Soc., 94 [11] 3605–3628 (2011)).

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