

COMBINED BRIDGMAN ANVILS FOR ULTRA HIGH PRESSURES

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Abstract

Combined Bridgman anvils comprising a central part made from superhard materials and an external cover made from metal ceramic based on cubic boron nitride are described. Used in diamond cells, these anvils produced pressure up to 50 GPa.

Key words: *high-pressure device, Bridgman anvils, superhard materials, cubic boron nitride, synthetic diamonds*

1. INTRODUCTION

Bridgman anvils [1] represent one of the simplest high pressure devices. Fig. 1 shows Bridgman anvils.

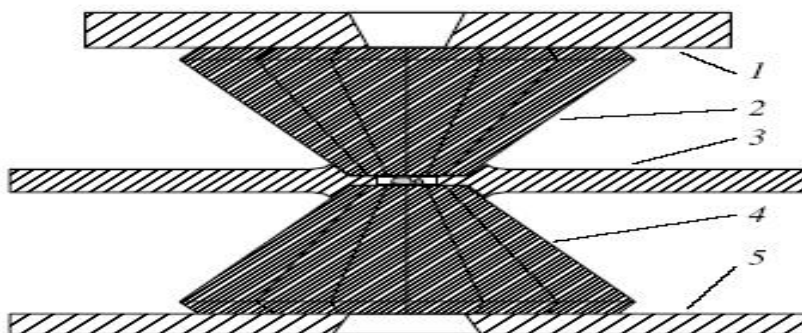


Fig.1

1, 5 – support for the anvils, 2, 4 – anvils, 3 – gasket

Two anvils (2, 4) made from a hard material and shaped as a flattened cone with apical opening of angle between 160 and 170° are drawn together by the axial force applied to supports (1, 5) and compress the gasket (3). In the central part of the gasket, a hole is drilled, where a pressure transmitting medium, a pressure sensor and a sample are located.

Anvils made from hard alloy provide pressures of up to ~10 GPa [2]. The highest pressures are reached when the jewelry-grade natural diamonds are used as the material for anvils. For example, in the study of the hydrogen melting curve, the pressure of ~200 GPa was achieved in diamond anvils [3]. Pressure sensors for the diamond anvils are ruby crystals, which luminescence R1 line shifts with the pressure.

As the cost of jewelry-grade diamonds is high, the weight of anvils is commonly several tenths of carat, while the diameter of anvil's work area does not exceed 0.5-0.6 mm at a height of 2 to 3 mm, and the support platform is 3 to 4 mm in diameter. So small dimensions of the anvil give the working volume where the maximum pressure is achieved of $\sim 10^{-2} \text{ mm}^3$ for the sample $\sim 0.1 \text{ mm}$ thick. This considerably limits the range of studies which can be performed using such anvils.

Recently, many new superhard materials were created by baking or directed impregnation with metals of diamond powders or cubic boron nitride powders. Such materials have somewhat lower mechanical properties than diamond, but they are much cheaper and can be produced in bigger sizes, about 10 to 20 mm in diameter and height. This paper deals with the use of such materials in the Bridgman anvils.

2. APPARATUS AND RESULTS

The previous paper [4] published in this magazine last year described the superhard material production technology based on cubic boron nitride (cBN), i.e. directed impregnation of cBN powders with aluminum under high pressures and at high temperatures. From this material, Bridgman anvils (Fig. 2) were made, one of which, paired with an anvil from transparent natural diamond, was tested in a standard diamond anvil cell (Fig. 3).

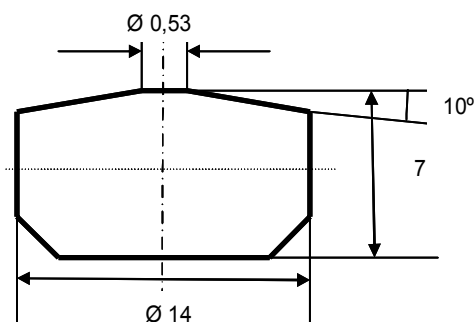


Fig. 2.

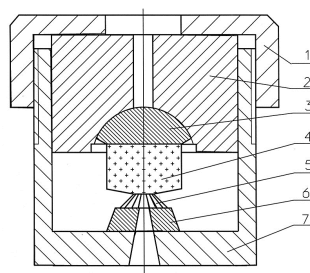


Fig. 3.

The force applied to anvils in the cell was created by a hydraulic press and fixed by a swivel nut, and after that the cell was placed to a spectrometer to measure pressure via ruby luminescence line shift. Ruby luminescence was excited by an argon laser. The maximum pressure achieved in this test was 36.2 GPa.

It appeared to be interesting to see how this superhard material would behave when used as a support for Bridgman anvil made from harder superhard material, for example synthetic polycrystalline diamond. Firstly, a polycrystalline diamond composite of Russian SV grade was chosen, having 3.5 mm in diameter and 2.5 mm high. This composite material consists of diamond crystals fixed by a binder representing a thin interlining between diamond crystals. The composite material was coaxially “baked” into a superhard ceramic in accordance with our technology [4]. The work piece obtained was processed to fit the dimensions of the pure ceramic anvil (Fig. 4). Fig. 5 shows the image of the upper surface of this anvil.



Fig. 4.

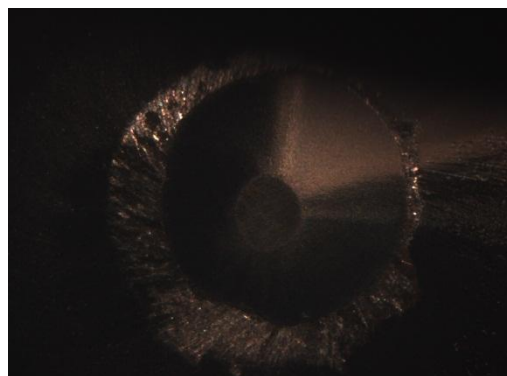


Fig. 5.

Paired with the natural diamond anvil, this anvil was tested in the high pressure diamond cell shown in Fig. 3. In the test, the maximum pressure of 42.2 GPa was achieved.

The same anvil was made using a diamond compact produced by baking of pure natural diamond micropowders without any binder. The compact was 6 mm in diameter and 4 mm high. This anvil paired with the natural diamond anvil was tested in a modified Bohler high-pressure diamond cell [5]. In this cell, the force is applied to anvils by controlled disk spring deformation. General view of this cell is shown in Fig. 6.



Fig. 6.

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In this test, the maximum pressure of 49.6 GPa was achieved.

5. CONCLUSION

The superhard material developed on the basis of compact forms of cubic boron nitride can be used to manufacture Bridgman anvils that operate in the pressure range of up to 50 GPa.

6. ACKNOWLEDGEMENTS

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