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A Simple High Pressure Apparatus Using Tungsten Carbide Balls

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High pressure apparatus of the opposed anvil type use conically shaped tungsten carbide anvils. The small flat faces of the conical ends of the anvils are massively supported and backed by the main bodies of anvils with much larger diameter. Newhall and Abbot[1] advocated the use of spherical anvils for generating high pressures. Spherical anvils are expendable because commercially available tungsten carbide balls cost less than one tenth of conically shaped anvils. We have exploited a new apparatus of the opposed anvil type using tungsten carbide balls. The apparatus is simple and is capable of producing pressures higher than 150 kbar.

A cross section of our apparatus is shown in Fig. 1. Commercially available tungsten carbide balls with 3 mm diameter of K20 grade (5–6% cobalt) are used for anvils. Unground spherical surfaces of the balls are used as the anvil faces. The other side of each ball is ground to make flat base with 2 mm diameter so that the anvil is prevented from rotation when the flatted base is pushed by a flat-ended piston rod. The anvils are coaxially alligned in a cylinder with 3 mm inner diameter. The cylinder is made of stainless steel, lined by thin bakelite which provides electrical insulation. The bakelite liner is strong enough and can be used repeatedly. The piston is made of drill rod.

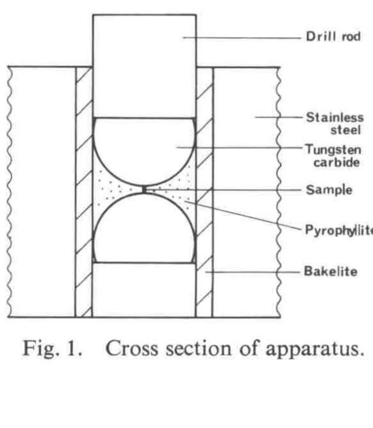

Fig. 1. Cross section of apparatus.

A pyrophyllite button gasket is placed between the adjacent spherical ends of the anvils so that the anvils are laterally supported. The initial thickness of the button at the center is carefully adjusted to be 0.28 mm. The choice of 0.28 mm is arbitrary. The effect of initial thickness on the attainable pressure may be large but has not been studied. A hole of 0.1 mm is bored at the center of button and powdered sample of semiconductor is filled in the hole.

The apparatus was loaded by a compression-testing machine. The electrical resistance of semiconductors was measured by a digital resistance meter. The pressure calibration was based on the semiconductor-metal transitions in ZnTe (about 105 kbar) and ZnS (150 kbar).[2] The resistance vs. applied load for ZnTe and ZnS in the present apparatus is shown respectively in Fig. 2 and the calibration curve is given in Fig. 3. When higher load was applied to

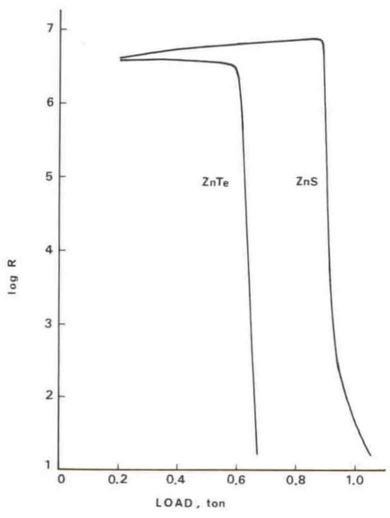

Fig. 2. Resistance vs. load for ZnTe and ZnS.

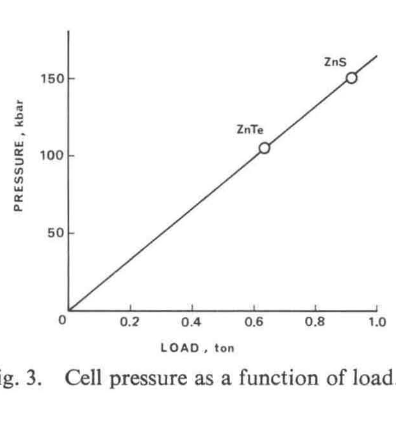

Fig. 3. Cell pressure as a function of load.

obtain the semiconductor-metal transition in GaAs at 180 kbar,[2] the spherical anvils cracked radially. The centers of anvil faces were found to be slightly dented. From the calibration curve, it can be seen that the present apparatus is capable of generating pressures higher than 150 kbar.

The configuration of the present apparatus is similar to that of the Drickamer type apparatus[3] except that ball anvils are used instead of conically shaped ones. The present apparatus is easier to make and operate. The present type apparatus can be improved to produce higher pressures:

(1) The strength of balls depends much on the diameter. The larger balls can carry the larger load. It is conceivable that higher pressures are obtainable by the use of larger balls for anvils.

(2) The tungsten carbide of K10 grade (4% cobalt) used widely for anvils of high pressure apparatus is stronger than that of K20 grade used in the present apparatus. Therefore, the use of K10 grade balls will increase the maximum pressure attainable. Polycrystalline diamond is much stronger than tungsten carbide. Bundy,[4] using polycrystalline diamond for anvil tips, stated that fabrication was one of the most difficult problems. If we contrive to get a spherical diamond, the limitation of the pressure produced will be significantly raised.

(3) The strength of ball anvils can be increased by stronger lateral support to anvil faces. A set of opposed ball anvils placed in another type of high pressure cell will generate much higher pressure. Such a type of apparatus is being studied at our laboratory.

References

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