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A New Method of Mounting Diamonds

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The conventional method of mounting a diamond for tool or other use is mechanical in nature. The diamond is either clamped in place or is held in place by a solder that does not wet the diamond. This method of mounting has inherent drawbacks that are eliminated when an actual bond is made between the diamond and its metal mount. Before describing the method of bonding diamond to metal, consider some advantages to be gained: (1) The diamond is anchored more securely to its mount. (2) The wasted “root” which in many cases is three-fourths the volume of the entire diamond can be eliminated. (3) Much smaller diamonds can be mounted to provide the same working surface. Sine diamond prices rise steeply with increasing size, a substantial saving results. (4) Heat transfer is undoubtedly better when a diamond is bonded to metal than when there is only a mechanical connection. This is important in the case of diamond tools. A cooler working diamond will wear longer (some wear is actually high-temperature oxidation) and is less likely to fracture from temperature shock.

Figure 1 illustrates a conventional method of mounting a diamond for a wheel dressing tool and compares it with the new method of mounting.

Diamond can be bonded to metal by the use of titanium hydride.[i] The technique is very similar to that used for bonding ceramics to metal.[ii]

The steps to be followed are: (1) Thoroughly remove all scale and oxide form metal parts. Follow this by degreasing in trichloroethylene or similar solvent. (2) Clean the diamond in a bath of molten $NaNO_3$-Na_2CO_3 mixture (approximately 50-50 wt percent). Use an iron crucible and heat to dull red. Leave the diamond in the bath until microscopic examination shows that the surface of the diamond has become slightly hazy or is covered with very tiny etch triangles. This usually requires a minute or two. Cool the diamond, wash it in distilled water, and dry. (3) Make a suspension of fine titanium hydride powder in amyl acetate. Add one drop of a noncarbonizing, volatile binder such as Zapon (cellulose nitrate solution) to the suspension. Paint the diamond

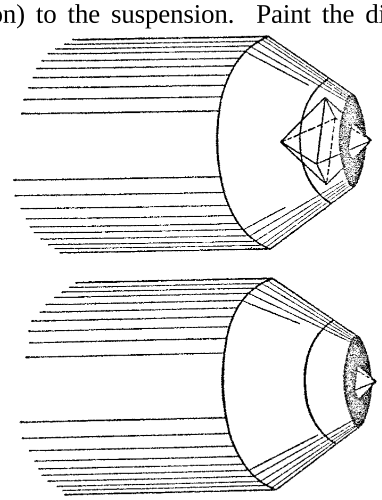

FIG. 1. Conventional method of mounting a diamond (top) compared with flush mounting with titanium hydride (bottom). Note diamond saving. Using the new technique, rough stones may be mounted with up to 90 percent or so of the stone *protruding*; whereas, up to 90 percent must be *buried* in a conventional mount.

and metal parts with the suspension. Take care to get a uniform coat. (4) Most any solder or brazing alloy melting between 400 and 1600° C may be used. Silver copper eutectic solder works very well. Place a thin sheet of solder between the parts to be joined and clamp them in place. (5) Heat the parts by induction or radiation heating in a high vacuum system. The vacuum system should have high capacity to remove rapidly evolved gases. Pressure should not exceed 0.01 micron at start of heat nor fall below 5 microns after heating. The bonding has been carried out also in very pure argon or hydrogen gas. (6) Cool slowly in the vacuum.

On complex work, it may be difficult to do the brazing in vacuum. Here is an alternative procedure that has been successfully employed.

1. Paint the etched diamond with titanium hydride solution. 2. Wrap the diamond in a thin foil of cobalt metal. 3. Support the diamond on a ceramic plate and heat in vacuum until the cobalt melts and coats the diamond. Sometimes the diamond will be bonded to the ceramic plate but this can be chipped away. 4. The cobalt covered diamond can now be soldered in place in air using standard solders and fluxes. The excess solder and cobalt is then sandblasted away from the working surface of the diamond.

Several single point wheel dressing tools using 0.15 to 0.25-ct boart have been made in this Laboratory. The boart was a roundish, dodecahedral shape. Each stone was mounted in a shallow cavity with titanium hydride and silver-copper eutectic solder. When finished, about three-fourths of the stone protruded from the mount. To obtain a rough comparison of these dressers with conventional dressers, cuts were made on a twenty inch diameter, four inch face, Norton 37 C54M5V, hard bond, vitreous, silicon carbide grinding wheel. The wheel was dressed smooth before starting the test. Then 0.001-in. cuts were made back and forth across the face of the wheel as it turned in a centerless grinder. Two conventionally mounted 0.25-ct diamonds "popped" from their mount on the first pass. The performance of diamonds bonded with titanium hydride was considerably better.

A 0.15-ct stone was still firmly bonded to its steel shank after 63 continuous passes. The tool was cooled with a spray of water.

A 0.20-ct stone was chipped but still firmly bonded to its steel shank after 86 consecutive cuts with coolant. It took 13 seconds for the diamond to traverse the face of the wheel so the diamond was cutting continuously for over 18 minutes.

In another test, a 0.20-ct stone was used to dress a sandwich type wheel in the centerless grinder. The wheel was a Norton 57A54K5VBE-57A80MVBE. Twenty cuts of 0.001 in. were made with coolant followed by 51 *without*. The diamond was chipped slightly but still firmly bonded to the steel. This same wheel was cut with a second 0.20-ct stone. Seventy consecutive 0.001-in. cuts were made without coolant. The bond between diamond and steel shank was unaffected.

E. F. Fullam, of this Laboratory, using the technique described above mounted a small diamond point on the tip of a microtome blade. At 56,000 rpm the force on the 2.5-mm2 bonding area was about 200 lb. This force was insufficient to dislodge the diamond.

As an item of interest, Leighly, and Walker,[iii] have found that diamond indentors often "stick" to titanium when used in hardness tests of that metal.

Some suggested uses for the diamond-metal bond are: (1) All types of diamond tools. Glass boring tools in which diamond powder is bonded to steel, boring bars, special ceramic cutting tools, and wire drawing dies in which the diamond die is bonded to the case have been made in this laboratory. (2) Diamond indentors for high-temperature hardness testing.

Diamond mounted with high melting solder or pure metal such as cobalt. (3) Joining small diamonds to obtain larger ones for large dies, etc., or to obtain different orientations of the diamond at certain places. (4) Obtaining good electrical contact with diamond for study of conduction under irradiation, etc., or to obtain good thermal contact for thermal studies.

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[i] Floyd C. Kelley, U. S. Patent 2,570,248.
[ii] R. J. Bondley, Electronics 20, II, 97-9 (1947).
[iii] H. P. Leighly, Jr., and H. L. Walker, Metal Progr. 62, 109 (1952).