CHAPTER 36

DIAMOND

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Photograph courtesy of Dr. Manfred Boretius, Listemann AG
Diamond, the hardest material known, finds numerous applications in industry, especially in the manufacture of ultrahard abrasives, metal machining tools, and drilling tools for oil and gas wells. Despite their high cost, diamonds are very effective tool materials. For example, the tool life of a polycrystalline sintered diamond is about 40 times longer than that of a traditional WC-Co cemented carbide cutting tool used for machining aluminum alloys. Other well-known applications include jewelry and electronic devices—particularly the heat sinking of diamond films and laminates, which employs extremely high thermal conductivity, another unique property of diamonds.

Brazing is the most reliable method of joining diamond to metals or ceramics. For this reason, many manufacturing companies and researchers concentrate their efforts on the research and development of diamond brazing technologies. This chapter reviews the conventional industrial materials and processes used to braze diamonds and presents promising new approaches that will hopefully be realized in the near future.

**BASE MATERIALS**

Five forms of diamond are available as ultrahard abrasive and cutting tool materials. They are as follows:

1. Natural single-crystal diamonds,
2. Synthesized single-crystal diamonds,
3. Polycrystalline diamonds (PCD) sintered at a high temperature and pressure,
4. Thick-film chemical-vapor-deposited (CVD) polycrystalline diamonds up to 0.04 inch (in.) (1 mm), and
5. Thin-film chemical-vapor deposited (CVD) polycrystalline (<0.002 in. [<50 micrometers (µm)]) diamonds.

The physical and mechanical properties of these diamond forms are compared in Table 36.1.

Thick-film CVD diamonds are manufactured in the form of wafers up to 0.04 in. (1 mm) thick and about 6 in. (150 mm) in diameter. These are cut by laser beam and brazed onto cemented carbide or a silicon nitride substrate. Thin-film CVD films are nucleated and deposited for cutting tools onto silicon nitride, silicon carbide, and WC-Co (with a low cobalt content, <6 wt %) cemented carbide substrates.

Diamonds are also classified by the presence of impurities or secondary phases. Most natural crystals belong to Type 1a, characterized by 0.1% nitrogen atoms in the form of small aggregates. Most synthetic diamonds are of Type 1b and contain dispersed nitrogen. Diamond crystals of Type IIa are substantially free of nitrogen and have enhanced optical and thermal properties. Very pure blue diamonds of Type IIb exhibit semiconducting properties due to a small content of boron.

Diamond possesses the highest hardness and highest thermal conductivity of any material at room temperature. The thermal conductivity of diamond crystals is as high as five times that of copper at room temperature. The unique combination of these two properties renders it the ultimate cutting and abrasive material. Diamond not only cuts the treated substance but also rapidly dissipates the heat.

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