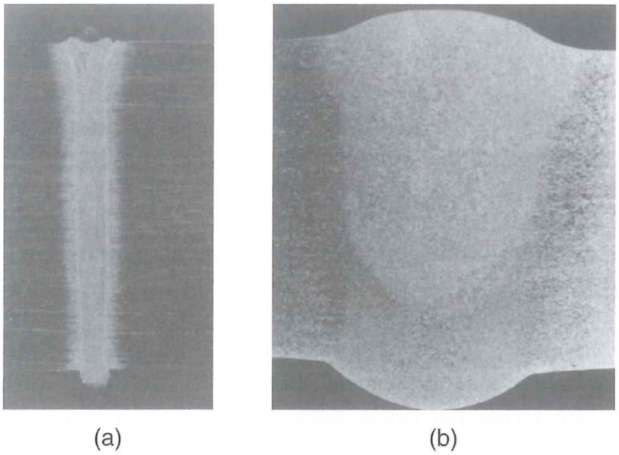

FIGURE 30.15 Comparison of (a) electron-beam weld and (b) gas tungsten arc weld. *Source:* Volume 3, *Welding Handbook, Welding Processes*, Part 2, Miami: American Welding Society, page 465. Used with permission.

30.7 Laser-beam Welding

Laser-beam welding (LBW) utilizes a high-power laser beam as the source of heat to produce a fusion weld. Because it can be focused onto a very small area, the beam has high energy density and deep-penetrating capability. The laser beam can be directed, shaped, and focused precisely on the workpiece; laser spot diameters can be as small as 0.2 mm. Consequently, this process is particularly suitable for welding deep and narrow joints (Fig. 30.15), with depth-to-width ratios typically ranging from 4 to 10.

Laser-beam welding has become extremely widespread and is now used in most industries. The laser beam may be **pulsed** (in milliseconds), with power levels up to 100 kW for such applications as the spot welding of thin materials. **Continuous** multi-kW laser systems are used for deep welds on thick sections.

Laser-beam welding produces welds of good quality with minimum shrinkage or distortion. Laser welds have good strength and are generally ductile and free of porosity. The process can be automated, to be used on a variety of materials, with thicknesses up to 25 mm. As described in Section 16.2.2, *tailor-welded sheetmetal blanks* are joined principally by laser-beam welding, using robotics for precise control of the beam path.

Typical metals and alloys welded include aluminum, titanium, ferrous metals, copper, superalloys, and the refractory metals. Welding speeds range from 2.5 m/min to as high as 80 m/min for thin metals. Because of the nature of the process, welding can be done in otherwise inaccessible locations. As in other and similar automated welding systems, the operator skill required is minimal. Safety is particularly important in laser-beam welding, due to the extreme hazards to the eye as well as the skin; solid-state (YAG) lasers also are dangerous. (See Table 27.2 on types of lasers.)

The major advantages of LBW over EBW can be summarized as:

- A vacuum is not required, and the beam can be transmitted through air.
- Laser beams can be shaped, manipulated, and focused optically by means of fiber optics, thus the process can easily be automated.
- The beams do not generate X-rays.
- The quality of the weld is better than in EBW; there is less distortion and the weld has less tendency toward incomplete fusion, spatter, and porosity.

EXAMPLE 30.2 Laser Welding of Razor Blades

A close-up of the Gillette Sensor razor cartridge is shown in Fig. 30.16. Each of the two narrow, high-strength blades has 13 pinpoint welds, 11 of which can be seen (as darker spots, about 0.5 mm in diameter) on each blade in the photograph. The welds are made with an Nd:YAG laser equipped with fiber-optic delivery. This equipment provides very flexible beam manipulation and can target exact locations along the length of the blade. With a set of these machines, production is at a rate of 3 million welds per hour, with accurate and consistent weld quality.

Source: Based on Lumonics Corporation, Industrial Products Division.

FIGURE 30.16 Detail of Gillette Sensor razor cartridge, showing laser spot welds.

QR Code 30.3 Laser hybrid welding. (*Source:* Courtesy of EWI)

QR Code 30.4 Hybrid laser arc welding. (*Source:* Courtesy of EWI)