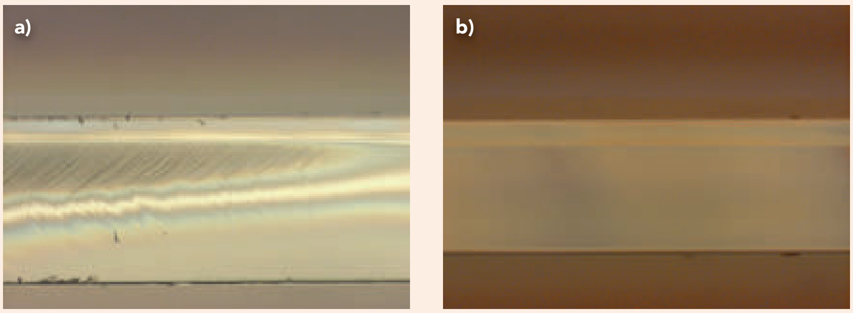
New CO laser offers high-power, 5–6µm output

Carbon monoxide (CO) laser technology was developed in the mid-1960s at the same time as CO_2 lasers. The CO laser was attractive because it had the potential to be 2x more efficient than CO_2 lasers. However, the CO laser presented challenges: Early CO lasers needed to be cooled to get high powers with high efficiency (very high-power versions were actually cryogenically cooled) and the laser output power would degrade quickly; typical lifetimes were tens of hours at most. Consequently, CO_2 laser technology "won" and has been the gas laser standard since.



Cross-sections of 0.7mm-thick Corning CT24 glass, taken with a Nomarski differential interference contrast microscope. The piece cut with a CO_2 (~10µm) laser (a) shows residual stress, while the cut produced with the CO (~5µm) laser (b) is defect-free.

Coherent has developed proprietary technology that allows for CO lasers that operate at very high output powers in the 5–6µm range at high efficiencies at room temperature and that last for thousands of hours. The new Coherent CO laser employs much of the same technology developed over many years for Coherent's CO_2 laser products. Coherent is developing CO lasers using waveguide and slab designs that will offer high average continuous-wave (CW) power and high-peak-power pulsed operation. Typical output power for CO lasers yields roughly 70 percent of that of a CO_2 laser. The CO laser version of the Coherent J-3 laser, for example, produces roughly 230W at ~5µm (at room temperature), while the same J-3-based CO_2 laser produces 340W at 10.6µm.

There are many benefits when materials processing at 5µm, the foremost of which is the "light-material" interaction advantage. At 5µm output, it will have significantly different interactions compared to CO_2 laser output simply due to the different absorption coefficients. It has stronger absorption in many films, polymers, PCB dielectrics, ceramics, and composites. Very low attenuation of the 5–6µm laser light in chalcogenide and heavy metal fluoride fibers open the potential for fiber delivery.

One application in which this difference in absorption coefficient has a significant impact is in glass cutting. In CO_2 laser-based glass cutting, the 10.6µm output is absorbed very strongly at the surface. The heat generated at the surface must then diffuse into the bulk material; subsequent water jet cooling is then used to produce a thermal shock, which creates a scribe line in the glass. For thicker glass substrates, this is followed by mechanical breaking. The overall process is the same with the CO laser; however, glass absorption of the 5µm output is much lower. Thus, the light penetrates directly and further into the bulk material, inducing heating more evenly throughout the thickness of the glass. Testing at Coherent has shown this to produce several important benefits, including no surface melting, no cracks, and zero residual stress in the glass. The result is a better-quality cut, stronger glass, and a wider cut process window (**FIGURE**).

Another important advantage is that the CO laser enables radial (free-form) glass cutting. In contrast, CO_2 lasers can only produce straight-line cuts because the inherently round output beam must be reshaped into a long, thin line beam to distribute the heat generated at the surface. Curved cuts are particularly important in smartphone display applications because curved corners or shaping to accommodate buttons and controls are often required. Curved and free-form cuts are possible with the CO laser, where the round beam penetrates directly into the glass without adverse heat effects caused by the difficult-to-control diffusion process.

The other major benefit of the 5µm wavelength of the CO laser output is that it can focus to a much tighter spot size with a longer depth of focus that allows drilling smaller holes and cutting with narrower kerf widths. The smallest spot size that can practically be achieved for a CO_2 laser is roughly 55µm, where the limit for the

CO laser is less than 25µm. On the other hand, achieving the same spot size with both wavelengths can be accomplished with smaller optics at the shorter wavelength. This in turn allows for smaller/faster galvo mirrors and other advantages in optical system design. The longer focal length that can be used with a shorter wavelength leads to a larger process window, allowing a larger field of view for area processing.

Another significant glass application is micro-hole drilling, such as that required in interposers for 3D circuit packaging. This application again takes advantage of both the focusability and controlled light-material interaction. Here, very small holes can be drilled with depth control and no heat damage/cracking.

The introduction of this new laser technology, enabling a new wavelength, is expected to open brand-new applications and enhance many current applications across the materials processing market.