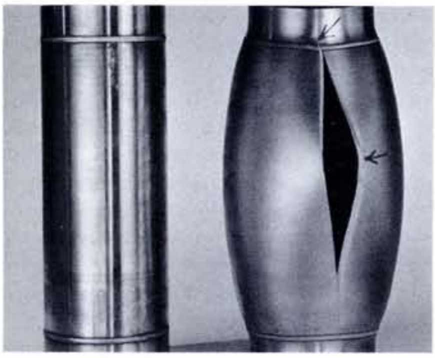

Fig. 2 — Pressure vessel test on CL5 laser-weld in 9mm stainless steel. The crack initiates at a stress raiser and runs cleanly across the weld.

such equipment, before and after being subjected to a standard pressure-vessel test. Allowing for beam-delivery losses in typical "production-line" systems, reliable welding at thickness greater than about 12mm demands powers in the 6-10kW range, or greater.

Two interesting sub-kilowatt laser cutting systems have been in use at the fast reactor centre of Dounreay. The first is at the post-irradiation examination cell for "topping and tailing" irradiated nuclear fuel subassemblies before they are sent in a transit can to the reprocessing building. The second is at the dis-assembly cave to open the transit can, and section the fuel wrapper.

As noted previously, the ability to scan high-intensity, carefully-localized heat patterns over metallic surfaces provides the opportunity for unusual case-hardening or other surface treatments, using basically the same laser equipment. Here, the potential technical and economic advantages over more conventional surface processes include faster production cycles, less distortion resulting in fewer rejects, and the elimination of post heat-treatment materials-processing. Laser hardened parts may be placed directly on the final assembly line, without costly grinding, honing, and straightening operations. In order of increasing power density, process complexity, and decreasing state of development, four distinct processes may be identified:

1. Martensitic transformation-hardening.
2. Surface alloying and cladding.
3. Creation of rapidly-quenched surface layers (laser and layer glazing).
4. Shock hardening.

Conclusion

Only some of the many exciting and innovative areas of application for lasers in industry have been outlined, but as constraints such as capital costs, running costs and system reliability become less restrictive, the areas continue to grow. In mass-production applications, and in markets which are sufficiently large for the laser system itself to be mass produced, such constraints are being considerably reduced all the time.

Optical Storage on Discs

G. Bouwhuis and J.J.M. Braat, Eindhoven

(Philips' Research Laboratories)

When storing information by optical means[1]), enormous densities of up to 10^8 bits/cm^2 are nominally possible and, with the aid of a spinning disc, high bit rates and random access are readily feasible. To record or scan the information track, it is clear that an adequate power has to be delivered to the scanning spot. For reading the data, the signal to noise ratio should be at least 20 dB, and in any case, the shot noise (photon noise) has to be well below this value. This means that for a data rate of 10 Mb/s, the power transmitted by the source through the optical system to the information spot has to be above 0.3 μW. At the same time, the size of the spot, limited by diffraction, implies a radiance that is certainly larger than 30W/cm^2 ster. This can not be attained with conventional sources owing to the short life-time or, with gas discharge lamps for example, the source noise.

For video discs, a signal to noise ratio of at least 35 dB of the photosignal is needed, demanding a radiance more than an order of magnitude larger. In these circumstances, a laser is the only possible source of illumination. Moreover, the power and beam quality that can be obtained from a laser, opens the possibility of recording by burning holes in a thin layer. Holes of 0.8 μm diameter can be formed in tellurium layers with an incident energy of about 1 nJ [2]), demanding a peak power from the laser source of at least 50 mW.

Early optical data recorders made use of gas lasers like the 1 W argon or krypton ion laser with, for modulation, an electro-optical or acousto-optical device. Recent progress however, in the development of the semiconductor AlGaAs laser has led to peak powers of up to about 100 mW being available which is amply sufficient for hole burning. A very attractive property of the semiconductor laser is that its output can be directly modulated with the drive current. Data rates of up to 30 Mb/s have been achieved[3]).

In order to attain the high information density, the scanning spot has to be as small as possible, typically of the order of 1 μm diameter. Such sizes can be obtained only with the aid of a fairly high numerical aperture of the spot-forming optics, which should produce virtually diffraction limited quality. The small size of the spot also requires the elimination of transverse modes in the beam. The longitudinal modes of AlGaAs lasers often show non-circular symmetry both in amplitude and phase distribution, but as the mode is basically diffraction limited, it can be fully adapted to the optics at the cost of a more complicated light path. In practice, the phase asymmetry is corrected by a weak cylindrical lens and although optical systems correcting the amplitude asymmetry exist, a simple optical system that collects only the central, uniform, part of the beam, is generally used.

As the spot diameter is proportional to wavelength, a small wavelength of the laser light is advantageous, and in this respect the He-Ne laser with a wavelength 20% shorter would be preferred to the present AlGaAs laser. Translated to the playing time of a video disc, the shorter wavelength implies a 40% gain, which is significant, since increasing the playing time by increasing the value of the numerical aperture, leads to tighter tolerances being imposed on the optical system and the disc parameters.

The effective spectral width of the source is important for the design of the spot-forming lens. Both types of laser are sufficiently monochromatic for a one-element aspherical lens to be used. However, a very small spectral width (a long coherence length) gives rise to unwanted interference effects due to light reflection at lens surfaces or diffusion by dust and scratches. Moreover, coherent feedback of radiation to the source may modulate the output of the laser. When using a He-Ne laser this is a nuisance whereas feedback to the AlGaAs laser can be exploited advantageously. A spot imaged on a reflecting information layer is inevitably re-imaged onto the source itself, and if no special means (e.g. polarized optics) are taken to avoid feedback, the output of the AlGaAs laser will vary according to the data in the track. The output modulation can thus be measured with a photodetector on the rear side of the laser, or directly in the driving circuitry: the source becomes then also the detector.

From the above, it can be concluded that the development now of high power AlGaAs lasers with long lifetime at room temperature has made optical recording a practical and powerful medium.

REFERENCES

1. Seven articles in *Applied Optics,* **17** (1968) 1993-2042.
2. Bulthuis K. et al., *IEEE Spectrum,* (1979) August, p. 26.
3. Bartolini R.A. et al., *IEEE J. Quantum Electr.,* **17** (1981) 69.