UV lasers make their mark in space, technology and surgery

ES Precision's new UV laser is paying for itself by opening up a range of valuable niche processing jobs, writes director **Andrew May**

A lab-on-a-chip designed to keep alive a microscopic worm in space, a PCB for advanced automation illumination, and a surgeon's orthopaedic power tools. What these technologies all have in common is that they were processed using a q-switched, frequency-tripled Nd:YVO4 (vanadate) laser, operating in the UV part of the spectrum with an output of 355nm.

The laser is the latest investment of ES Precision, a firm that since it began in 2017 has consistently reinvested profit to expand service offerings to UK manufacturing. Key to our success in fine laser processing is the wide range of lasers available – five distinct types across eight laser workstations. The wavelength outputs of these, which range from near-infrared and infrared to UV, mean we can modify the surface of virtually any material, from exotic to mundane. Typically this is a mark by surface transformation – oxidation, ablation, foaming, annealing etc – or, for very thin materials, clean cutting.

The company wanted to be able to create attractive, functional marks on any material that our customers use. We handle all metals, sometimes with coatings such as anodising or paint, from aluminium to platinum. There is a wide range of ceramics too, but it is organic materials which probably present the most diversity; there is such a wide range of plastics and rubbers, and each might appear in varying formulations, incorporating fire-retardants, glass fills or a multitude of pigments.

Some plastics are formulated by the masterbatch supplier with specific additives designed to enhance laser marking. This can be expensive and many moulding companies cannot dictate the formulation they use – that will be decided by their customer. From time to time, ES Precision used to receive polymer components which could not be marked satisfactorily.

The way that lasers interact with materials is primarily driven by their wavelength; organic materials tend to absorb well at the UV and far infrared ends of the spectrum, but sometimes not so well in between. Seeking to meet the demands of medical device customers for permanent, high-contrast marks, without reformulating the material, we began to test sources of other wavelengths. While CO_2 lasers are also used for such substances, treatment with their 10,600nm output tends to be more thermal than with UV's 355nm. The UV laser can avoid burning, charring and melt-back.

Laser marking is usually cleanest if the material is surface-absorbing, and the transmission spectra of many polymers show an increased absorption (decreased transmission) below about 400nm wavelength (see figure 1), and this is often enhanced if additives are incorporated.

ES Precision's new UV laser has established a niche in processing materials hitherto thought to be unsuited to laser marking. There are also applications where the UV results outshine cruder marks from infrared lasers, in terms of contrast, resolution and crispness (edge quality). Aside from better surface absorption, mark quality also benefits from the smaller →

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Figure 1: Transmission of polycarbonate plummets wavelengths below 400nm

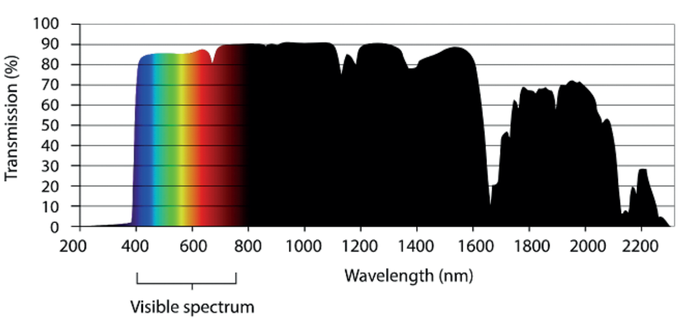


Figure 2: Laser cut membrane in polycarbonate for a microfluidic assembly

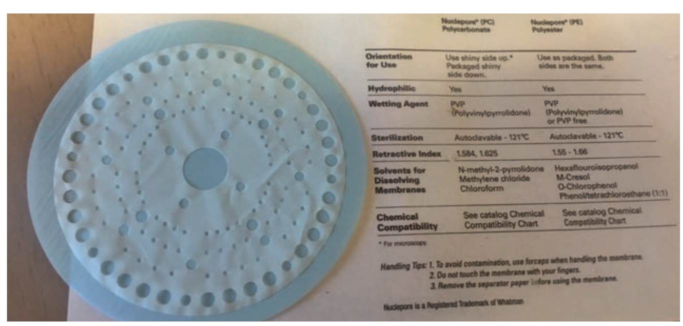
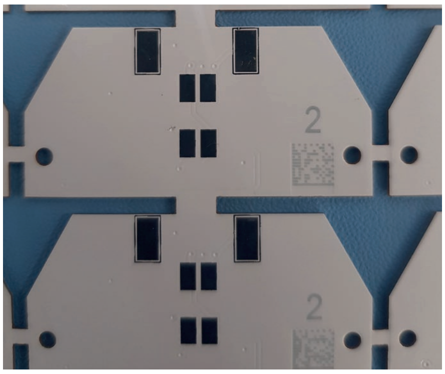


Figure 3: Unique ID matrix codes marked on PCB resist



focal spot size and reduced thermal damage achieved when using the shorter wavelength.

So why don't all laser subcontractors offer a service for laser marking using UV lasers? The answer is that they are no panacea – most metals and ceramics absorb better at the near-infrared – so it is necessary to operate a suite of laser types. The other argument is economic – UV laser markers can be twice as expensive as infrared ones, and typically offer a fraction of the average power. Shorter wavelength lasers cost more; ES Precision operates laser markers delivering 200W of CO_2 (10,600nm) average power and 100W of Nd:YAG (1,060nm), but only 3W of UV. This modest power means that marking throughput can be slower at the short wavelength, so commercial returns would be reduced for routine jobs if a laser with a fraction of the power at twice the capital cost was used.

ES Precision's new UV laser has nonetheless paid for itself by opening up valuable niche jobs. Our experience of operating the laser for a year or so has shown a steady accumulation of applications from several sectors. These are mainly from newer industries, such as the examples we describe below – space, microelectronics and surgical tools – which often use materials that have not always been readily available in the past. This includes the micron-range hydrophilic polycarbonate membrane used in the lab-on-a-chip application for the space sector.

Worms in space

A Cranfield University team of students has been selected for a project with the Swedish National Space Agency, German Aerospace Centre, and European Space Agency, to investigate the effect on a complex life form of an extended period in space. They chose the caenorhabditis elegans nematode – a 1mm worm, which has many genes with functional counterparts in humans. The task will be to keep it alive in a compact environment in preparation for it to be launched as a satellite, beyond a low earth orbit. The team have designed a 'bioCubeSat', which incorporates a microfluidic assembly that can be pressurised and used to feed nutrients and drugs to the nematode in orbit.

Such fluid assemblies tend to be made by laminating layers of polymers, often laser-cut to create functional channels linking feeding and sensors for monitoring the experiment. ES Precision used its new UV laser to create complex profiles in thin (a few microns) polycarbonate membrane (see figure 2), with minimal thermal damage.

Unique ID matrix on a PCB

Another example of our newest laser being put to use was in an application for bare board supplier PCB Partners and their end-customer Esprit Electronics, who required their white solder resist on the boards to be permanently marked with tracking information in the form of a tiny ID Matrix code (see figure 3). Each code encrypts a series of alphanumerics incorporating a unique tracking code for optimal quality assurance for the automation illumination that they control. The only laser that would produce a reliably readable mark with sufficient contrast was the UV marker.

Permanent, clean traceability for the operating theatre

The final example of our new laser being used that I'll share here was a job for De Soutter Medical, which makes powered tools for use in orthopaedic and trauma surgery. Medical technology is a field which always demands traceability and cleanliness, so components must be cleanly and permanently marked with product numbers and regulatory graphics. The cord sets which link instruments to controllers and power supplies tend to be made using a flexible silicone rubber that can be tough to get an excellent mark on with traditional lasers, however our UV laser was able to produce a very fine, dark print (see figure 4).

Figure 4: Essential regulatory graphics and a unique ID matrix code on a medical cord set

Going forward

Looking to the future, forward-thinking service providers will be seeking to continue to invest to be able to produce better, faster marks on all manner of products. Some materials present laser processing challenges owing to their conductivity (pure gold, graphene), others due to their transparency (quartz, some glasses) and yet others due to their fragility (bio materials such as collagen, and thin materials such as graphene). Deeper UV sources (such as excimer lasers) provide some answers, as will ultrashort pulse lasers, such as those in the femtosecond range. As always, the cost-benefit for such big-ticket items will need to stack up before small, high-tech laser processing businesses consider investing.

> "UV lasers will continue to find applications for which they are the best source"

UV lasers will continue to find applications for which they are the best source, and sales growth will lead to greater commoditisation of a hitherto specialist product. Price reductions are often quite slow to reach the marketplace while sales volumes remain relatively low. Historically, the very cheapest lasers from the Far East have been available in frequency doubled, and even tripled, formats, but reliability and support for these imports is often woeful.

Untapped potential

While newer cutting and marking tasks, such as those described above, cross our desks from time to time, my feeling is that there is still a significant untapped market from manufacturers who would like to benefit from the many attractions of laser marking, but believe that it won't give them the results they need. 'We tried laser marking – it didn't work'.

These companies are still making do with alternative functional or tracking marking, such as sticking labels on their products; using ink which rubs off; managing without unique coding; or labelling the box, rather than the actual product.