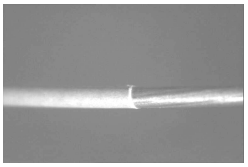
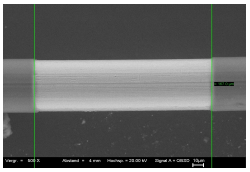
Excimer Laser Stripping of Insulation (wires & pads)





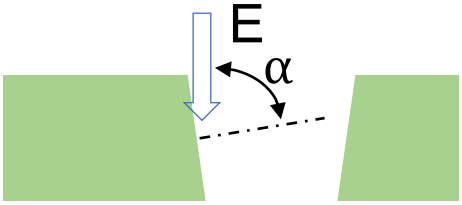
The stripping of the insulation from fine wires is a fairly well-known application of both CO_2 and excimer lasers through a non-contact process that is efficient, clean & precise, and offers ZERO wire damage. CO_2 laser offers excellent selectivity coating/metal and ability to remove a wide range of polymer coatings/enamels; wire dia at upper right is 0.3 mm, sheath PTFE.

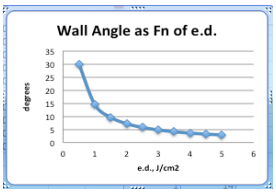
However lateral resolution is somewhat limited by the wavelength, and a recognized limitation of CO_2 laser stripping is its inability to strip the final few μm of the coating; once the thickness is less than $\lambda/4$ the beam has no way to interact with the material! Frequently an additional process step is required to remove this residue. Excimer laser stripping does not suffer from the latter limitation, and affords much higher lateral resolution, lower right shows a wire of 50μm dia.

Excimer laser wire stripping can be on free ends or isolated sections, can include bundles, with excellent stripping deep down into the interstices, and can include for e.g. opening of 'windows' onto the individual wires of spirally laid cables, with part translation/rotation synched to laser firing.

It might seem obvious that insulation is only removed from the region directly exposed to the laser beam, so that stripping round the full 360° of a wire should logically mean either rotating the part, or using multiple, or scanning, beams, whilst the layout of the part dictates which method is the most appropriate in any particular case. It is always so?

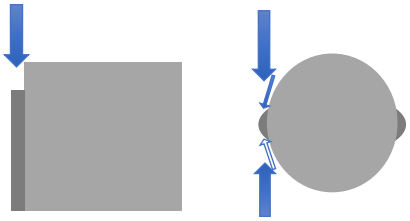
In the evening, it gets cooler because the suns rays hit the earth obliquely, so incident energy density falls as the cosine of AOI;- and of course the same is true of laser beams. In the same way, the wall angle in excimer machining (left) varies with incident energy density E_0 because as α approaches 90° the effective e.d. normal to the surface , $E_0 \cos \alpha$ falls below the threshold for ablation E_T, so that α establishes itself according to $\alpha = \cos^{-1} (E_T / E_0)$.



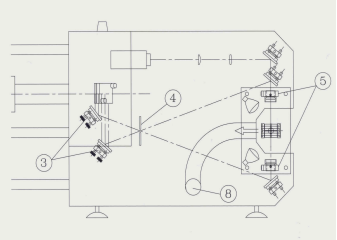


Fitting typical numbers, wall angle (90-α) predicted in this way (right) turns out to be somewhat on the big side, however there are two indications that grazing incidence reflection from the wall itself actually enhances local e.d. significantly (logically, the limit would be 2X, but predictably somewhat less);- angle IS significantly higher at the entrance before such reflection has kicked in, and there is usually a pronounced 'dip' at the foot of the wall in a blind hole.

In the same way, with a perfectly collimated laser beam, one would not expect to be able to strip from a vertical surface, except possibly by slowly ablating away 'on the edge' as at left though in connection with one project I argued, and proved, that one can never strip from an extended vertical surface,- it simply is not possible to get the beam in there.

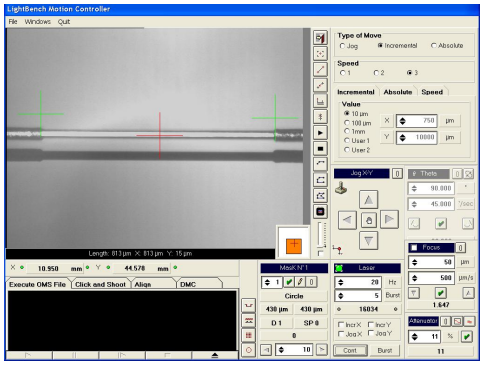


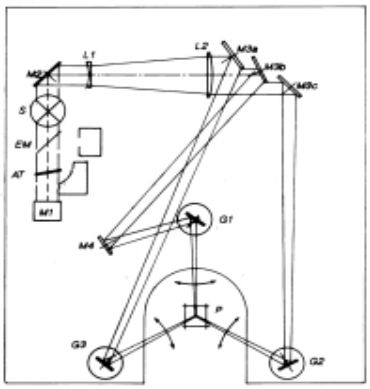
Nevertheless, for a thin enough wire one can get a 360° strip using just 2 beams. It makes sense, for a circular section wire the surface is only vertical at one singularity, and the vertical depth to be ablated through 'on the edge' as above is then not that much more than the insulator thickness. Plus, there will be some helpful grazing incidence reflection from the already stripped metal,- small arrows. It does require more shots, and sometimes higher energy density, to finish the sides, but 2-sided stripping has been used in many Optec systems for medical products, up to wire diameter on the order of 200μm. For thicker wires, 2-sided does not work as well,- which makes every sense in terms of the model above.



The 'Compact Wire Stripper' shown schematically on the right was designed to fit directly onto the front of a small excimer laser, and is shown in lateral elevation, laser(not shown) is on the left. Parts are inserted into the 'jaws' of the stripper at the right, where beams from both above and below irradiate the wire according to a mask (4)(optional), using twin process lenses(5). The 'target' was a flat wire cable in this case, but the same principle can be used to fine round wires. Fumes are extracted rearwards(8). Lighting and Vision is provided through the upper dichroic mirror, to a zoom inspection microscope.

An alternative approach is to use a retro-reflector to reflect the part of the beam that misses the 'wire' in 'front'(direct) exposure, and redirect it to the back side of the wire. The optic has to be carefully selected and positioned to ensure the correct registration of the 'front' and 'back' exposures, whilst at the same time ensuring identical process parameters. The TTL (through the lens) screen image on such a system typically shows the wire from above (upper wire) and, by retroreflection, its silhouette (lower), facilitating axial alignment of the upper & lower strips.

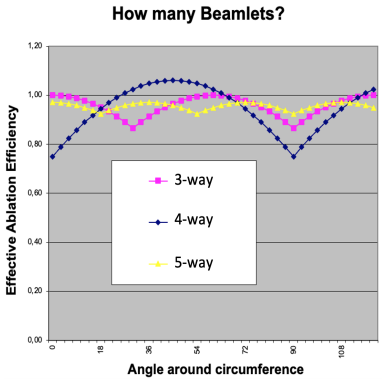




WIRE STRIPPING BDU – OPTICS LAYOUT

A concept 3-beam stripper is shown at left, in this case with a larger laser. The 'wire' was actually a wire bundle of quite large size compared to the beam size, so beam scanning was used with three galvo mirrors G1-3.

In that case the complete BDU was mounted on a bracket to the (larger) laser with manual adjustment for the axial location of the stripped zone, w.r.t. the part handling on customer side. The BDU body can also be modified to allow insertion/translation of the part along the horizontal perpendicular to the wire axis.



Somewhat counter-intuitively, uniformity of exposure around the wire circumference is NOT improved by a four-way split; a 5-way split does improve matters, but also starts to become overly complicated. Centre-left image below shows a 3-way stripper for wire bundles.

Most commonly, stripping is required of a partly assembled component, where part geometry & handling determine the optimum approach. Optec can advise on optimum solutions, which can range from simple lab tool(left) to fully automatic production workstations,- centre right for wire stripping in cleanroom assembly of hearing aids, right for electrode stripping on catheter tips.

Another common application is stripping of contact pads or exposure of embedded conductors, a few examples are shown, all stripped using Optec workstations using either excimer or Impact CO2 TEA lasers:-