Understanding the Multiwave Hybrid™ Processing of Silicone

Material Description

The term silicone refers to a broad group of siloxane base synthetic rubber materials, the most common of which is polydimethylsiloxane (PDMS). PMDS consists of a repeating chain of silicon and oxygen atoms with methyl groups bonded along the chain (see Figure 1). This combination of organic groups bonded to an inorganic backbone gives silicone a unique set of properties.

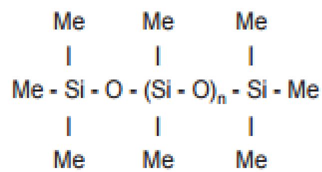

Figure 1. Silicone structure – a long dimethylsiloxane chain that is terminated on each end by a trimethylsilyloxy group [1].

Silicone exhibits a high thermal stability and chemical resistance making it an excellent material for high temperature seals, especially in automotive applications. It is an excellent electrical insulator, and is often used as a high temperature insulator on wires that are exposed to extreme environments. Its broad temperature range (-100 to +250 C) make it ideal for many aerospace applications.

Laser Processing Observations

Silicone sheets up to 1/4" thick can be cut with a CO_2 laser. The laser cutting leaves a tarry gray residue along the cut edge and on the silicone surface near the cut edge. This residue is a mixture of silica and depolymerization byproducts such as silanol [2 and 3]. The residue can be removed by scrubbing the silicone with soapy water. This leaves a smooth, clean cut edge.

Silicone is also engraved for forming rubber stamps. The engraving can be done very precisely, with a high level of detail. However the residue mentioned above is an issue. Because the engraving is usually intricate it is very difficult to remove all of it, even with vigorous scrubbing.

Hypotheses Regarding Multiwave Hybrid Processing of Silicone

Based on the literature review the residue that is observed after laser cutting and engraving can contain as much as 98% nanocrystaline silica (SiO_2). Since silica is largely transparent at a wavelength of one micron (see Figure 2), it is not likely that combining a fiber laser beam with the CO_2 laser beam will help to vaporize the residue. However since we are not certain of the complete composition of the residue, a Multiwave Hybrid laser process with 10.6 μm and 1.06 μm wavelengths should be tried.

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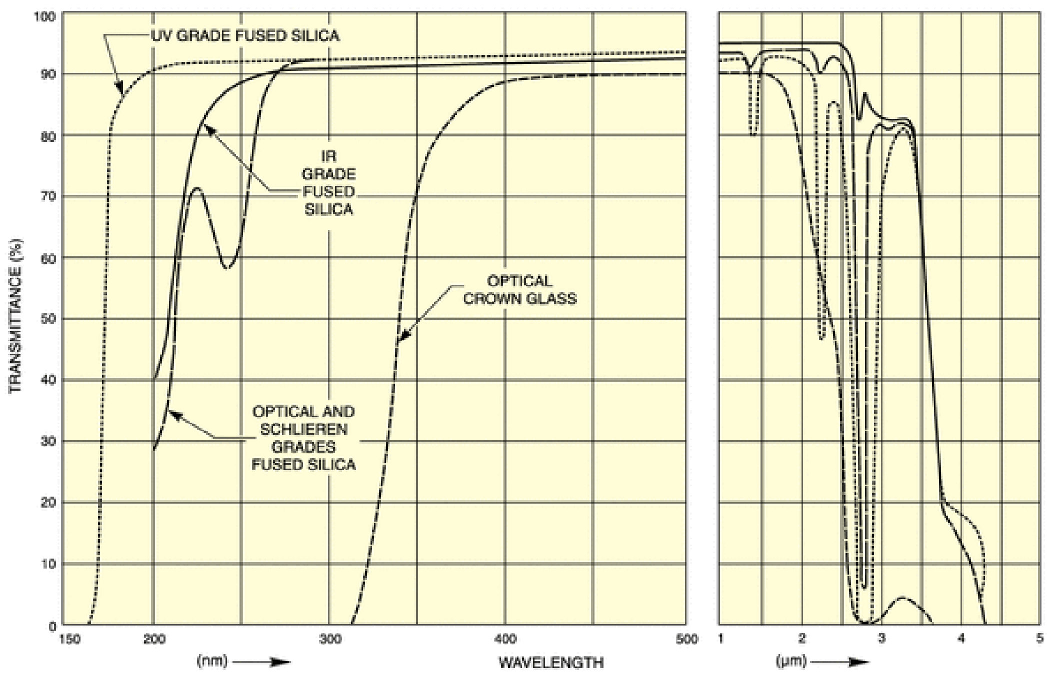

Figure 2. Optical transmission spectra for various grades of fused silica.

Another approach to eliminating the residue would be to use a high pulse energy CO_2 laser. The increased pulse energy would be likely to vaporize the silica component of the residue as well as the silanol component

Testing our Hypotheses for Multiwave Hybrid Processing of silicone

The Multiwave Hybrid approach to cutting silicone will be simple to test. First cut a simple shape from a sheet of silicone using two 75 watt CO_2 lasers with the Materials Database settings. Next cut an identical shape using the same setting for the CO_2 lasers, with the addition of a 50 watt fiber laser at waveform zero. This will deliver the maximum 1.06 μm energy component to the silicone, and have the best chance of vaporizing the residue. Compare the two pieces without cleaning to see if there is an advantage. Next run a similar comparison test for laser engraving.

References

1. A. Colas, "Silicones: Preparation, Properties and Performance" Journal of the Royal Chemistry Society, Belgium (2005).
2. B Budden, "Some Like it Hot", whitepaper, Dow Corning Corp.,
3. I. Ferguson, "Analysis of Laser Processed Silicone", ULS Internal Report.