Introduction to Laser Material Processing

Laser material processing utilizes laser energy to modify the shape or appearance of a material. This method of material modification provides numerous advantages to customers such as the ability to quickly change designs, produce products without the need for tooling, and improve quality of finished parts.

Another advantage of laser material processing is compatibility with a multitude of materials. Compatible materials range from non-metals such as ceramics, composites, plastics/polymers and adhesives to metals including aluminum, iron, stainless steel and titanium. This document describes the effects produced by laser energy interacting with a material and the laser processes that can be applied to almost any material.

Laser Energy-Material Interaction

The effects produced by laser energy interacting with a material strongly depend upon the wavelength and power level of the laser, and the absorption characteristics and chemical composition of the material.

Common wavelengths for laser material processing are 10.6 and 9.3 micron produced by CO_2 lasers and 1.06 micron produced by fiber lasers. A range of power levels are available for each laser type to optimize the laser energy-material interaction. However, the absorption characteristics and chemical composition of the material and the desired results will greatly influence the selection of the laser type and power level.

The effects of the laser energy-material interaction are **material ablation** and/or **material modification**.

- **Material ablation** is a physical process that removes material. Material is removed completely from the top to the bottom surface or partially from the top of the material down to a specified depth.
- **Material modification** is a physical process that alters the properties and/or appearance of a material.

Material ablation is used for cutting, engraving and marking with depth. Material modification is used for marking on the surface of a material by changing the appearance or properties of the material. The terms cutting, engraving and marking are commonly referred to as laser processes. Depending on material compatibility, a single laser process or multiple processes in any combination can be applied to a material.

The following chart summarizes the results of the laser energy-material interaction and relevant laser processes.

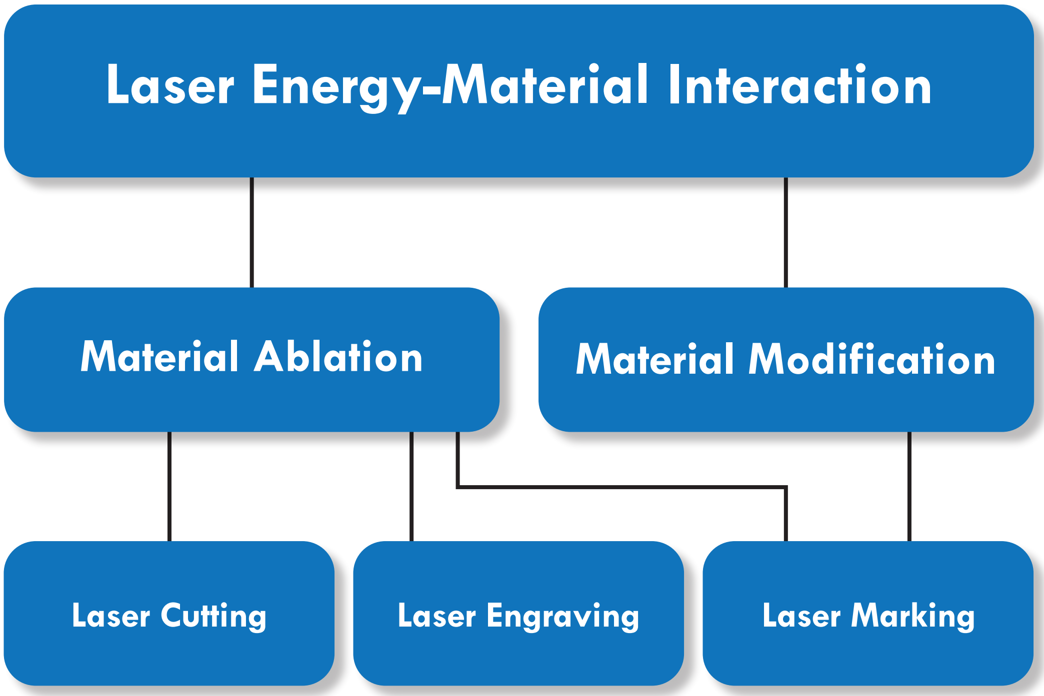

Figure 1: The derivation of laser processes from laser energy-material interactions

Laser Processes

Cutting

Laser cutting is the complete removal and separation of material from the top surface to the bottom surface along a designated path. Laser cutting can be performed on a single layer material or multi-layer material. When cutting multi-layer material, the laser beam can be precisely controlled to cut through the top layer without cutting through the other layers of the material.

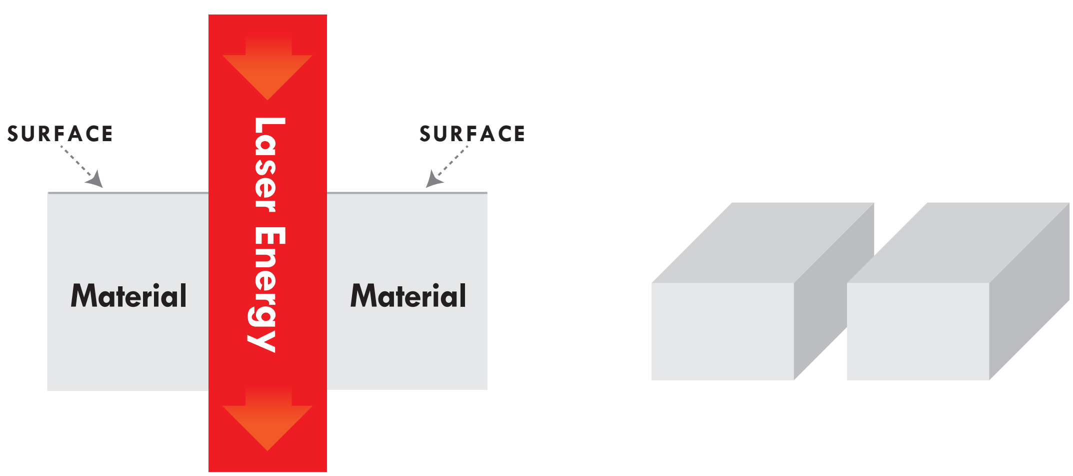

Figure 2: Laser Cutting

CO_2 lasers with 10.6 micron wavelength are primarily used for cutting non-metal materials. CO_2 and fiber lasers are both used for cutting metals; however, as a rule, cutting metals requires substantially higher power levels than non-metal materials. Material thickness and density are important factors to consider when cutting. Cutting through thin material requires less laser energy than cutting the same material in a thicker form. Lower density material typically requires less laser energy, however increasing laser power level generally improves laser cutting speed.

Engraving
Laser engraving is the removal of material from the top surface down to a specified depth.

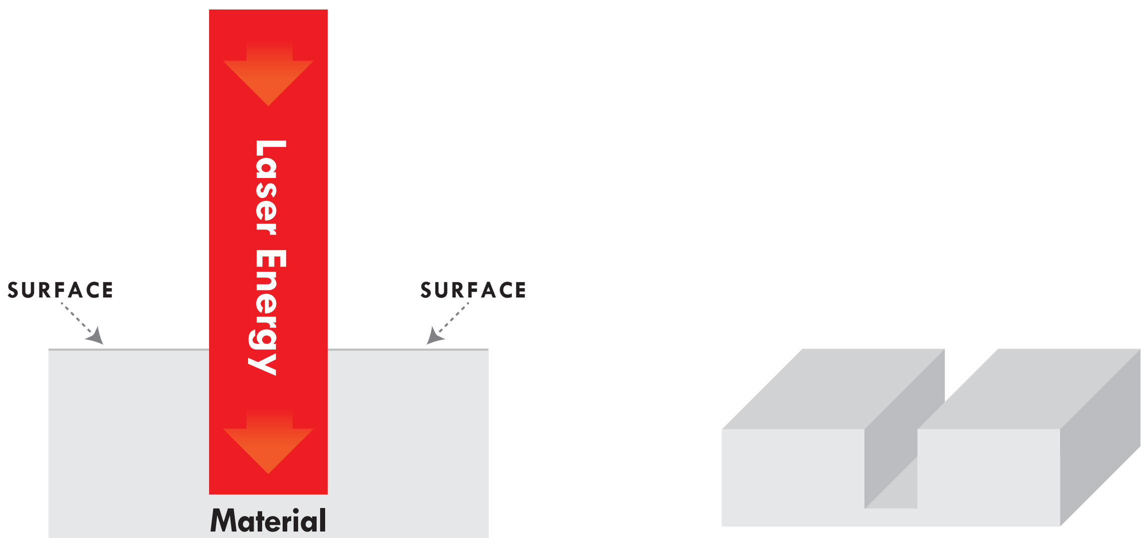

Figure 3: Laser Engraving

CO_2 lasers with 10.6 micron wavelength are primarily used for material removal to engrave non-metal materials. The material type and laser power level determine the maximum engraving depth and speed of engraving. Typically shallow engraving is a faster process than deep engraving. Additionally, lower density materials engrave faster than higher density materials. Increasing laser power level generally improves laser engraving speed.

For metal engraving, CO_2 lasers are not typically used, because most of the laser energy is reflected. However, fiber lasers with 1.06 micron wavelength can be used for shallow engraving into metal.

Marking (Depth and Surface)

Marking is the production of human- and/or machine-readable identification or information on a material, such as a barcode, date/lot code, serial number or part number. Other information including logos, diagrams, illustrations and photographs can also be marked on a material.

With laser marking, the laser removes material to create depth (laser depth marking) or modifies the material to change the color, contrast or reflectivity of the surface (laser surface marking). Most materials can be laser marked, but results will vary depending on the laser wavelength used. Both 10.6 micron and 9.3 micron CO_2 lasers are used for marking non-metal materials with depth, as well as for surface marking of some metals. Fiber lasers with a 1.06 micron wavelength are used for surface marking of many materials and surface or shallow depth marking of metal. Laser depth marking is sometimes referred to as engraving *(see Figure 3 for illustration)*.

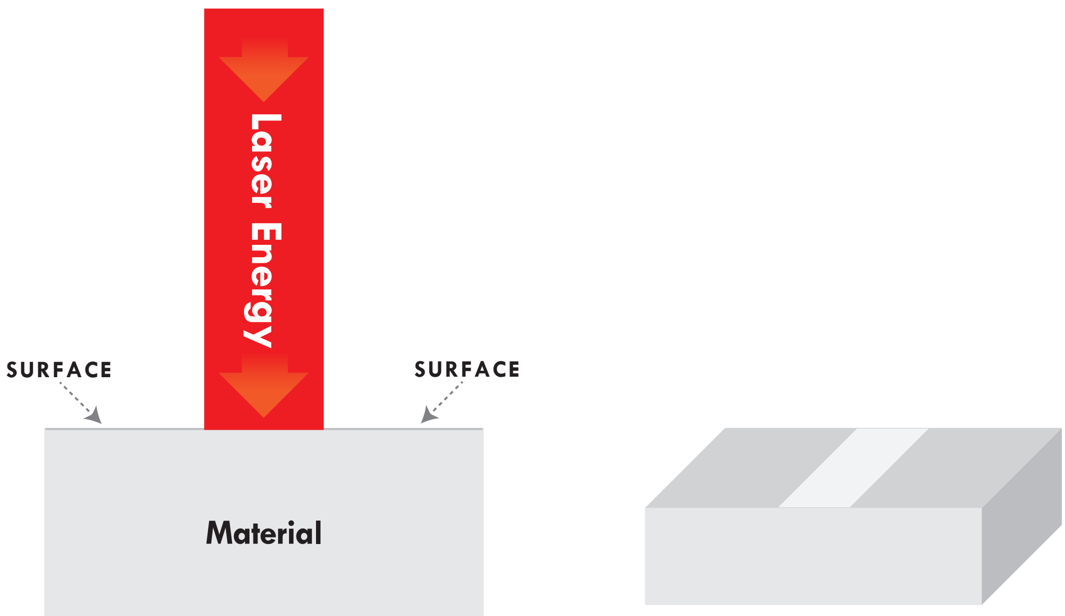

Figure 4: Laser Surface Marking

Conclusion

Laser material processing offers real time flexibility and enhances the process of designing, developing and introducing new products. With a wide range of materials available for use, this technology is a viable option for almost any industry or environment.

To start exploring laser material processing possibilities for your materials, contact Universal Laser Systems.

About ULS

Universal Laser Systems develops customizable DLMP™ (Digital Laser Material Processing) solutions to offer the highest capability, flexibility, and performance lasers and laser system solutions for advanced material processing. Universal's DLMP™ solutions consist of a range of lasers, laser systems, capability enhancing accessories, advanced software interfaces, and an extensive, intelligent material processing database.