

CO2 Laser Basic Knowledge

Materials & Possibilities of Processing



Taufenbach Laser · developed and produced in Germany
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Introduction

CO₂ lasers with a wavelength of 10.6 µm have been tried and tested for decades in industrial material processing. The wavelength is in the mid-infrared, where many organic materials have a very high absorption rate. This means that the laser energy is converted directly into heat – precisely, quickly and without mechanical contact.

Wood

Properties

Wood contains lignin and cellulose, which absorb strongly in the mid-infrared range. The laser energy is immediately converted into heat at the surface, which makes the material locally evaporated or charred.

Advantages

Very clean cut edges, fine engravings, high level of detail even with thin or filigree geometries.

Typical Applications

Architectural models, furniture components, signs, decorations.

Advanced knowledge

Strong absorption by O–H stretching vibrations in cellulose and aromatic structures in lignin. Relevant vibration bands approx. 9–11 µm.

Beer-Lambert: $I(z) = I_0 \cdot \exp(-\alpha \cdot z)$. Large $\alpha \rightarrow$ fast absorption at the surface.

Plastics (acrylic, ABS, PETG, PC)

Properties

Many plastics absorb 10.6 µm radiation strongly. Acrylic, for example, melts locally and results in a polished cutting edge.

Advantages

Post-processing often not necessary, flexible shapes possible.

Typical Applications

Displays, illuminated signs, housing covers.

Advanced knowledge

C–H stretching vibrations and C=O groups in the polymer couple in the mean IR. Thereby the material melts locally and solidifies smoothly.

Heat flux density: $q = P/A$. High $q \rightarrow$ local melting without large-scale thermal load.

Paper, cardboard, leather, textiles

Properties

Cellulose and natural fibers absorb almost completely at 10.6 μm . Precise
Cuts without compressive loading.

Advantages

No tooling costs, pattern changes possible digitally.

Typical Applications

Packaging, prototyping, design, leather engraving.

Advanced knowledge

As with wood: O-H bands in cellulose. Leather also contains proteins (collagen), which are
IR strongly absorb.

Absorption coefficient α is high $\rightarrow$ low penetration depth. This creates very
clean cut edges.

Glass & Ceramics

Properties

Glass is transparent in the visible range, but absorbs at 10.6 μm at the
Surface.

Advantages

Decorative engravings without chemicals or printing processes.

Typical Applications

Drinking glasses, bottles, technical markings.

Advanced knowledge

Si-O stretching vibrations approx. 9–11 μm $\rightarrow$ CO2 laser energy couples directly to the
glass surface .

Energy input: $Q = \alpha \cdot I \cdot t$. Microcracks appear on the surface $\rightarrow$ matt engraving.

Paint and coating layers

Properties

CO2 lasers can remove thin layers of paint or paint in a very targeted manner without the material underneath. This is used to create fonts, logos or make data visible.

Advantages

Contactless and permanent removal of paint layers.

Typical Applications

Example: Removal of varnish on glass lids (e.g. jars), to have a best-before date or a batch number.

Advanced knowledge

Absorption mostly in organic pigments or binders (C-H/O-H bands). The Energy is sufficient to vaporize the layer locally.

Local energy density: $E = (P \cdot t)/A$. Limit defined when paint peels off, without substrate

Metals (limited)

Properties

Pure metals reflect CO2 laser light strongly. Direct processing only possible to a limited extent.

Advantages

Surface markings by coatings or oxide layers.

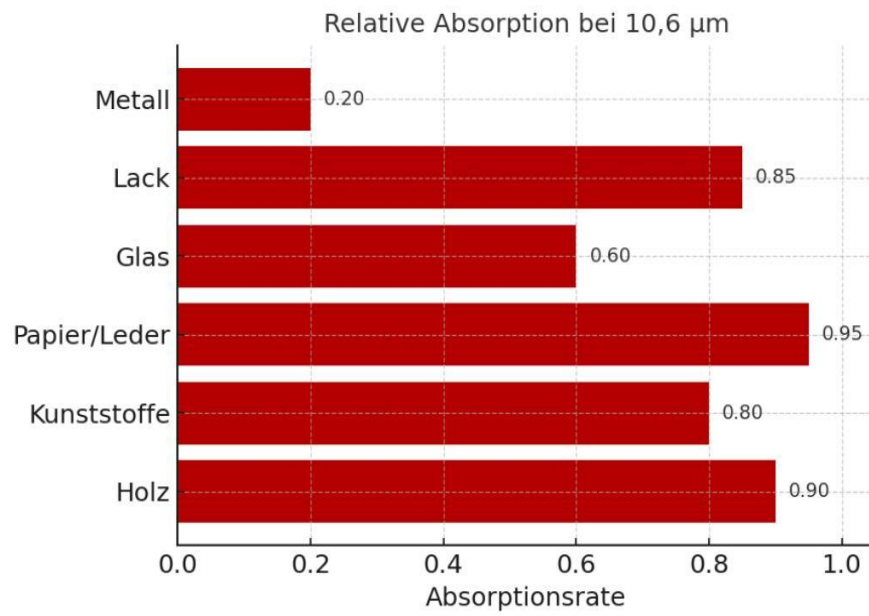
Typical Applications

Nameplates, tool markings.

Advanced knowledge

Free electrons lead to high reflection in IR. Absorption usually only via oxide layers/additives.

Reflection R high, absorption A low. $A + R = 1$ 1st example: $R \sim 0.95$, $A \sim 0.05$ at $10.6 \mu\text{m}$.



Result

The CO2 laser is the first choice for organic materials, transparent Plastics and coated surfaces. Its wavelength fits very well with absorption bands of many materials, which enables efficient, precise and economic processing . For metals, on the other hand, specialized Laser sources required, such as fiber and other solid-state lasers

Material	Possibility with CO2	Typical Uses
Wood	✓ Cutting / Engraving	Models, furniture parts, Signboards
Synthetics	✓ Cutting / Engraving	Displays, Signs, Case
Paper/Leather/Textiles	✓ Cutting / Engraving	Packaging Prototypes, engravings
Glass/Ceramics	✓ Surface engraving	Glasses, bottles , Decor
Paints/Coatings	✓ Ablation / Exposure	Best before date batch marking
Metals	✗ limited	Nameplates, tool markings

Haftungsausschluss / Disclaimer

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