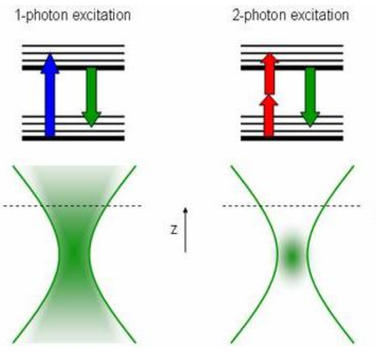
Highlight

Aachen,
January 30, 2013

Test of polymer laser welding based on two-photon absorption mechanism

PolyBright's Task 4.9 covers the investigation of two photon absorption process in connection with laser polymer welding. Due to the fact that multi-photon absorption takes place only at high photon fluxes (Figure 1), a focused, high-power 532 nm (green) pulsed Nd:YAG laser is used for investigating the interaction with a PA66 foil, which is transparent for 532 nm and absorbing at 266 nm (Figure 2). At distances close to focal plane (so-called "z-scan"), beam-foil interaction is clearly observable but results in polymer decomposition instead of polymer melt required for welding purposes (Figure 3).

Figure 1: Comparison of one-photon absorption (left) and two photon absorption mechanism (right), which takes place only in the central region of a focused, pulsed high-power laser beam.



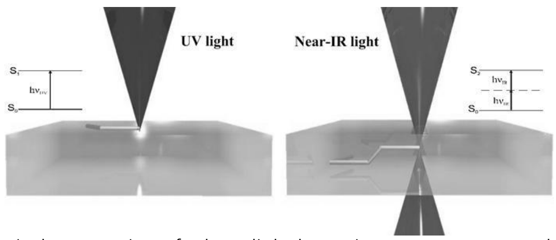


Figure 2: Optical penetration of a laser light beam into a transparent polymer, assumed to have a near-infrared or visible wavelength of 532 nm (right) or to have a ultraviolet wavelength of 266 nm (left). The latter can occur if the photon flux of the (pulsed) visible 532 nm beam is high enough to enable two-photon absorption. While the PP or PA66 polymer is transparent for 532 nm, it is absorbing at 266 nm.

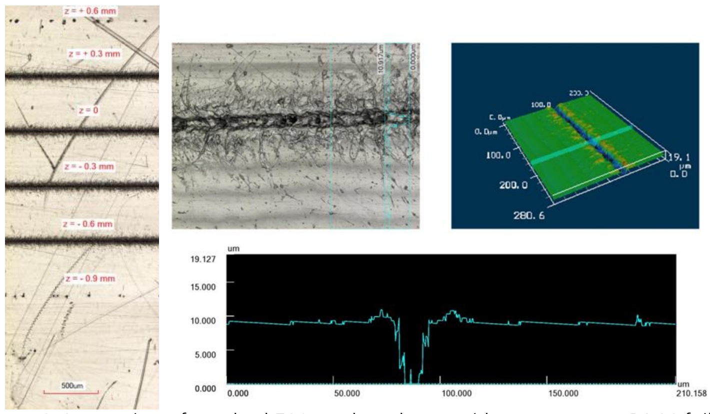


Figure 3: Interaction of a pulsed 532 nm laser beam with a transparent PA66 foil as function of foil position relative to focal plane ("z-scan", left) and surface inspection of the z=0 line (3 photos at right side). Laser: frequency doubled Q-switched Nd:YAG, pulse length 610 ps, repetition rate 20-40 kHz, pulse energy 100 µJ, average power 2,5 W, lens f=100mm.

SEVENTH FRAMEWORK PROGRAMME

The process of two-photon absorption was theoretically already discussed 1931 by Maria Goeppert-Mayer. It has a very small interaction cross section compared to regular one-photon absorption, which is equivalent to using powerful, short-pulsed focused laser radiation for observing two-photon processes. PolyBright's WP4 experiments reveal a clear observable interaction between a transparent PA66 polymer and green 532 nm pulsed laser radiation. Laser energy is converted to polymer decomposition but not to create a polymer melting zone. This is similar to using pulsed visible laser radiation for well-known interior glass cube engraving (see figure 4) where a focused laser beam spot generates scratches below surface.

Figure 4: Glass interior engraving with laser radiation

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