Announcing the Final Examination of Ali Abdulfattah for the degree of Doctor of Philosophy

Time & Location: March 25, 2020 at 9:00 AM in CREOL 103
Title: 2 MICRON FIBER LASER MACHINING TRANSPARENT CONDUCTIVE GLASSES & TRANSPARENT POLYMERS

Recent years have seen significant development steps in Mid-IR fiber laser, especially thulium-doped fiber (TDF) lasers, which are now contributing to new highly attractive applications in many applied fields. One of these new directions is TDF-laser machining of transparent tin conductive oxide (TCO) glasses and transparent polymers (TP). TCO glasses and TPs are in use widely in many fields such as renewable energy with solar cells, future LCD panels, medical devices, the auto industry, and many other areas. This line of research is still new, to our knowledge. This dissertation describes research work investigating the micromachining of TCO glasses and transparent polymers using nanosecond TDF (ns-TDF) laser pulses at the 2-micron wavelength region. This work has not been reported in published scientific publications.

The objective of this study is the science of the light-matter interaction between ns-TDF laser and TCO glasses and transparent polymers. This interaction results in surface micromachining using a direct laser writing (DLW) method for TCO glasses and transparent polymers. Also, TP polymers can have subsurface micromachining as an additional interaction investigation. The ns-TDF laser was designed, fabricated, optimized, and tested in house for this light-matter interaction work. Several ns-TDF laser systems have been studied and developed through a sequence of development and operation optimization research investigations. The ns-TDF laser produces a 100 ns pulse duration with a 100 kHz repetition rate with up to 1.1 W average power. The 3D machining stage is computer-controlled with 0-10 mm/s scanning speed.

Both Zinc oxide (ZnO) and Indium tin oxide (ITO) glasses were the only glasses in entire investigation study of TCO glasses. Fluorine-doped tin oxide (FTO) were also tested in early investigations. The ns-TDF laser wrote successfully selected removal lines by the DLW method on both ZnO and ITO thin films deposited on lime glass. The separated thin films on both written lines were non-conducting electrically, indicating a sign of successful interaction. Several morphology textures have been observed and studied in both ZnO and ITO. The effect of laser pulse energy to the machining scan speed for both TCO glasses and TP polymers are investigated to draw an energy scale machining map.

Poly (methyl methacrylate) (PMMA) and polyethylene terephthalate glycol (PETG) were the transparent polymers investigated for surface and subsurface micromachining with a ns-TDF laser. The surface micromachining morphology structure of written lines using the DLW method for variable applied laser energy was investigated. Subsurface micromachining for PMMA and PETG was demonstrated at several depths from near-surface close to the back surface. Several observations, recorded and investigated. Laser pulse energy played a significant rule effect on subsurface micromachining. Polylactic acid (PLA) films showed successful micromachining interaction.

Major: Electrical Engineering

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Approved for distribution by Martin Richardson, Committee Chair, on February 27, 2020.
The public is welcome to attend.