The Value of Laser Material Processing Technology in Higher Education

Introduction

Laser material processing technology is widely used at colleges and universities as a means to provide students with hands-on experience in applying their academic knowledge to the development of practical solutions to real world science and engineering problems. Incorporating technologies such as laser processing into academic curricula not only benefits students, but also helps to establish a foundation for collaboration with industrial companies.

Laser material processing technology is playing an ever-increasing role in industry, from basic process development to product manufacturing. This technology converts graphic designs directly into working parts, making it ideal for rapid prototyping. It is used to process materials without any physical contact, and without the need to create tooling or fixtures, thereby facilitating flexible manufacturing environments. When coupled with automated materials handling systems, laser technology is used extensively for high-volume manufacturing. These benefits apply across virtually all industries, including consumer electronics, automotive, aerospace, defense and energy.

To support the expanding role of laser material processing in industry, academic institutions around the world have incorporated the technology into their educational curriculums. Laser systems have been placed in academic laboratories where they support educational programs ranging from fabrication of engineering prototypes to development of novel material processing technologies. These advanced programs provide direct benefits to students and faculty. Ultimately, these benefits are realized in industry through a highly-educated and skilled workforce.

Laser Material Processing Technology in Higher Education

Academic institutions have long relied on a combination of classroom lectures to instill scientific and engineering principles, and laboratory exercises to provide practical experience. The laboratory courses not only provide students with hands on experience, but they also provide opportunities to develop practical solutions to current engineering problems. This combination of classroom and laboratory learning is essential to foster the growth of our future scientists and engineers.

For example, at Stanford University, students in the Aerospace Program use laser technology to fabricate components for autonomous aircraft (Figures 1 and 2). Fabricating the components and assembling them into functioning aircraft gives students an opportunity to apply what they have learned about aerodynamics and aircraft control systems, to create an integrated solution.

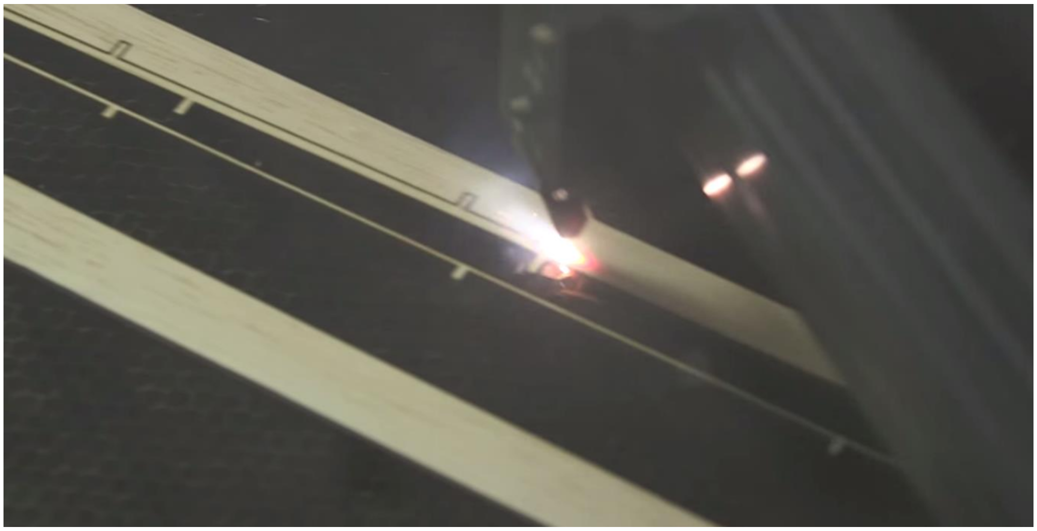

Figure 1. Laser cutting the structural components for an autonomous aircraft.

Figure 2. Laser cut components being assembled into a wing structure for an autonomous aircraft.

"The most important thing the students get out of this class is the ability to put together an entire system. Once the students complete this course and successfully fly their aircraft, they have the capability to go out into industry and do the same thing." says Juan Alonso, Associate Professor, Aeronautics and Astronautics, Stanford University. Laser technology plays a key role in engineering courses such as this, providing students with knowledge and skill that they will carry with them throughout their careers.

Laser material processing technology can be utilized for a virtually unlimited number of materials including plastics, metals, fabrics and composites. For example, Politechnika Wroclawska in Poland used laser processing technology to create microreactor components using sheet acrylic. The process involves simply downloading a design file, such as the one shown in Figure 3.

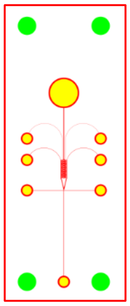

Figure 3. Drawing for a microfluidic device (in PDF format).

The shapes and colors in the design file are translated buy the laser system into an instruction set for laser processing the full component. After downloading the design to the laser system, the user selects the material name from the *Materials Database,* which in turn automatically downloads the optimum laser process settings for that material. Then the user presses the *Start* button on the laser system controller to initiate laser processing. The finished component is shown in Figure 4.

Creating a new component with different features or dimensions can be done by simply changing the drawing. There is no new tooling or fixturing to create. This allows rapid cycles of learning, which benefits faculty by accelerating research and development programs. Students also benefit by learning rapid prototyping techniques that leverage the unique capabilities of laser material processing technology. This experience will be valuable to them throughout their professional careers. Based on this experience, employers will seek out these candidates over and above graduates without similar material processing experience.

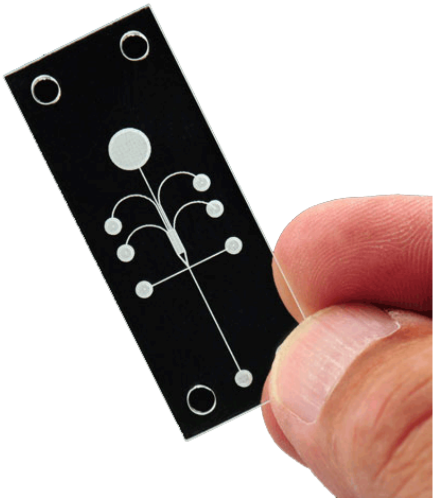

Figure 4. Microfluidic device created by laser material processing technology.

Laser material processing technology also plays a key role in scientific research. At Rice University's Smalley Institute for Nanoscale Science and Technology a team of researchers, under the direction of Prof. James Tour, is extending the frontiers of materials science by using a CO_2 infrared laser to create Graphene from commercial polymers [1].

Graphene is a hexagonal array of carbon atoms that is just one atomic layer thick (see Figure 5). It has an electrical conductivity that is nearly double that of copper, and is 100 times stronger than steel. Due to its superlative properties, Graphene has been one of the major topics in materials science and engineering in recent years. Unfortunately conventional methods for creating Graphene are both expensive and time consuming.

The team at Rice University has overcome this hurdle by using the infrared beam from a CO_2 laser to convert commercial polymers to Graphene. The process is done in air, avoiding expensive vacuum equipment. It is a direct-write process, eliminating the need for time-consuming film transfer processes. The Rice team has used their Laser Induced Graphene (LIG) process to create high-performance supercapacitors. This represents a significant advancement in Graphene production technology, with the potential to enable high volume roll-to-roll manufacturing processes.

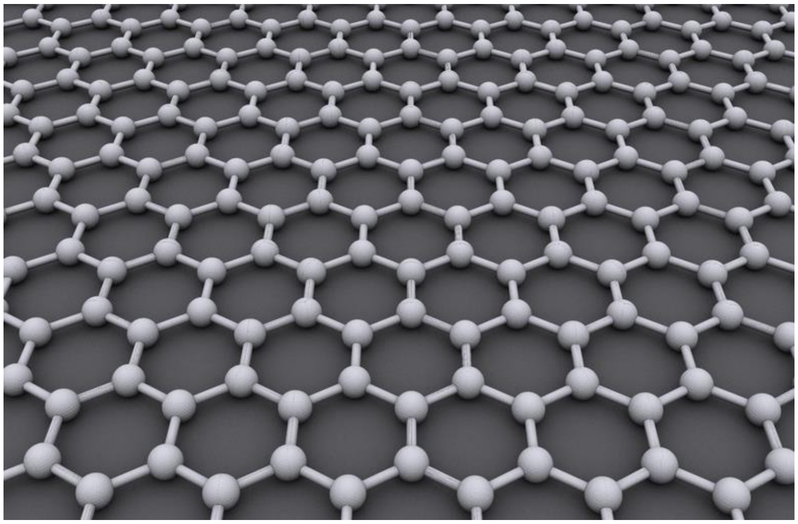

Figure 5. Schematic representation of graphene.

The three case studies described above illustrate the valuable role that laser processing can play in academic institutions; from providing a robust platform for rapid development of new design concepts to enabling new scientific advances.

Summary

The benefits of laser material processing technology in Higher Education are realized at many levels. Students, both graduate level and undergraduate level, receive the direct benefit of hands-on experience with the advanced technologies that they are learning about. Professors are provided with an environment for exposing their students to practical engineering challenges. The capability of the research community to develop new material processing technologies is enhanced through access to state-of-the-art equipment. University administrators are able to further the research agendas for their institutions through the establishment of advanced material processing centers. The industrial community also benefits from having graduating students entering the workforce with practical experience in laser material processing technology.

References

1. Lin, J.; Peng, Z.; Liu, Y.; Ruiz-Zepeda, F.; Ye, R.; Samuel, E. L. G.; Yacaman, M. J.; Yakobson, B. I.; Tour, J. M. (2014). "Laser-Induced Porous Graphene Films from Commercial Polymers". *Nature Communications* **5**: 5714.