Lasers and Their Applications in Singapore

Anand ASUNDI and Yu YANG
Centre for Optical and Laser Engineering (COLE) School of Mechanical and Aerospace Engineering
Nanyang Technological University, Singapore

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Since the laser was firstly demonstrated in 1960, numerous applications of lasers have been developed for the manufacturing, electronic, consumer and medical industries. This paper reviews the current laser-related technology activities in Singapore, it includes the laser source development, industrial laser application in manufacturing and measurement as well as scientific research in different field done by different organizations and companies in Singapore.

Key Words: Industrial lasers, Laser applications, Laser manufacturing

1. Introduction

The industrial application of lasers involve a wide range of fields, such as material processing, telecommunication and information processing, sensing & measurement, etc. Laser material processing is the most dominating of the industrial laser applications which covers common processes including welding, cutting, drilling that affect the physical properties of a material. The laser beam acts as a heat source in the process, and also a form of energy can be highly intensive concentrated by focusing. Lasers are able to produce high energy concentrations due to their monochromatic, coherent, and low divergence characteristics comparing to ordinary light source. As a result they can be used to heat, melt, and vaporize the materials. High power lasers make them ideal tools for many material processing applications. Laser beam require no physical contact with the material, they have the advantages over most of the conventional methods involving mechanical drill bits or saws. It is also possible to deliver a laser beam to remote locations and to incorporate lasers with automated machinery. The most common processing materials can be ranging from metals, ceramic, silicon, plastic, etc.

Laser technology has become essential in the information technology and will become much more important in the future. Semiconductor lasers are currently extensively applied in the applications related to the processing, storage, and high speed data transmission. They are accepted as "the light of the future", due to their compactness, easy integration and high output powers. These applications involves a diversity of areas, such as telecommunications, optical disks (CDs & DVDs), optical computing and display. Light offers several advantages over other technologies, it has a higher frequency than radio or TV waves which are modulated by electric signals in copper wire. In optical storage devices, there is no physical contact with the medium, which means no wear or losses from frequent use. The unique properties of laser light have created new areas of information manipulation that were not possible before.

The characteristic of coherent allows laser in use of interference effects to discover the changes in stressed object and minute changes in distance, while the directionality of the beam provides for long distance projection and range finding. Monochromatic laser beam is useful in studying the absorption and fluorescence of a wide range of materials. The un-

Table 1 General laser applications.

| Application          | Property of beam most used | Laser normally used                  |
|----------------------|----------------------------|--------------------------------------|
|                      | Mono- | Low | Coherent | High | Single | Efficient |
| Powerful light       | chromatic | divergence | power | mode |        |
| Alignment            | He/Ne, argon                |
| Measurement of length| He/Ne, ruby, Nd-grass       |
| Pollution detection  | Dye, GaAs                   |
| Velocity measurement| He/Ne, Nd-grass             |
| Holography           | All, mainly visible         |
| Speckle interferometry| He/Ne, ruby                |
| Inspection           | Nd-YAG                      |
| Analytical technique | GaAs, GaAsP                 |
| Recording            | He/Ne, GaAs, iodine         |
| Communications       | CO2, Nd-YAG or glass, excimer|
| Heat source          | CO2, ruby, argon, excimer   |
| Medical              | He/Ne, argon, copper        |
| Printing             | Dye, argon, copper          |
| Isotope separation   | CO2, Nd-glass               |
| Atomic fusion        |                            |

Main property; Second property; Third property.
usual properties of laser light can be also used in a variety of ways for industrial instrumentation applications including measurement of velocity, angular rotation rate, surface profile and finishing, material strain, vibration and defect detection so on so force. The general laser application with laser light unique properties is shown in Table 1.

Since laser can be applied in such many areas, there have been lot of laser related research projects done by institute, universities, polytechnics, as well as industrial companies in Singapore. The industrial laser market distribution and revenue are shown in Fig. 1.

2. Research & development

Currently most of the R&D activities are performed in the government funded research institute and tech centres in the university, there are several research institutes carry out laser processing research and laser related development.

The Data Storage Institute, one of the 14 research institutes of the Agency for Science, Technology and Research (A*STAR), has an Optical Materials and Systems Division that performs research on laser interactions with materials and industrial applications of laser micro- and nano-processing and characterization for the data-storage and electronics industries. Its facility has a broad range of pulsed UV to IR lasers. Many projects involve students from local universities and the full-time staff in the R&D activities, and some of the development projects are carried out in collaboration with local industry.

The Singapore Institute of Manufacturing Technology (SIMTech) develops high value manufacturing technology and human capital to enhance the competitiveness of Singapore’s manufacturing industry. It is a research institute of the Agency for Science, Technology and Research (A*STAR).

SIMTech has completed projects for companies, big and small, in the electronics, semiconductor, precision engineering, medical technology, aerospace, automotive, marine, logistics and other sectors. SIMTech has broad laser capabilities to address the range of industrial interests. Its 10 in-house laser systems include femtosecond, DPSS UV, 200-W fiber laser, and a 3-kW CO₂ laser. R&D activities encompass both micro- and macro-processing, including microprocessing of brittle materials such as silicon and glass, precision dicing and drilling of electronic substrates, and machining of composites materials, laser cutting, drilling, welding, and laser additive processes (cladding). SIMTech has established a reputation working with industry and has many collaborative and technology-transfer projects with companies in the different industrial sectors. An example of collaborative work with industry is the laser drilling of precision holes in composite material.

Recently, emphasis has been placed on the laser additive process laser sintering, which enables the building of nearly net-shaped parts using powder materials, along with the advantage of depositing more than one material at a time to produce graded materials with tailored mechanical properties. With a newly installed powder-delivery nozzle and twin powder hopper, collaborative work with several aerospace maintenance repair overhaul companies has been initiated.

The Centre for Optical and Laser Engineering (COLE) launched in 2013 is dedicated to latest instrumentation and laser processing technology development and industry transfer. Some of the research and technologies available include high resolution 4D optical metrology systems, optical instrumentation for bio-imaging, diffractive optics design and testing and laser material interaction such as etching of diamond, graphene removal, invisible marking in transparent materials and other micromachining applications. COLE aims to be a research centre where cutting edge research in the area of Optical Engineering that is currently dispersed in the School will come under one roof. With more than $30 million of funding from industry and the Singapore government, COLE is home to some of the world’s leading experts and latest technology in optical engineering. The strong pool of qualified researchers would contribute to manpower and talent development to address the growing needs of this sector. This will also pro-

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Fig. 1 Source: Optech Consulting said that the industrial laser systems market was up 5% in 2013, reaching a new record level of $10.7 billion dollars. (Image credit: Optech Consulting).

Fig. 2 Laser processing of microfluidic channel from DSI.
vide one stop shop for industry interaction through projects and consultations. The centre hopes to attract leading researchers and scientists from around the world for collaborative projects, short courses and conferences and seminars. It would thus be a magnet for budding optical engineers starting from the High School and Polytechnics to undergraduates to choose a career in Optical Engineering.

Centre for applied photonics and laser technology (CAPLT) in Ngee Ann Polytechnic was formed in 2006, focus on the optical metrology and laser system development. The current project includes developing industrial grade laser sources for material processing, digital holography microscope and other in-house project of optical inspection system. It was firstly demonstrating a high efficient deep UV 213 nm solid state laser up to 30 mJ output with 15% IR to UV conversion.  

3. Industrial laser system manufacturers

Most of industrial laser manufacturers have a local office in Singapore for their sales and technical support service purpose in Southeast Asia region. One of the biggest laser manufacturer in the world Coherent opened a new manufacturing facility in Singapore recent years. This new center is equipped with the capacity to produce entire laser sources for laser marking, laser ablation, scribing, laser drilling, and photovoltaic manufacturing applications. The 32,000 sq. feet. center also operates to support the company’s global customers. Coherent anticipates doubling its workforce to more than 200 within the next few years, mainly in high level engineering and research positions.

TRUMPF has a sales office and demonstration facility with a Nd:YAG laser on a robot arm. It competes with other metal working companies and supplies laser cutting systems to the local industry. German-based EOS, a supplier of laser sintering systems for rapid prototyping and manufacturing, will establish a support center later this year to address the rapid growth of its user base (> 100) in the Asia-Pacific region. Rofin has a center in Singapore that assembles high-value marking systems and services the Southeast Asian region, offering sales, training, service, and spare parts (Rofin-Baasel Singapore Pte. Ltd.). Rofin-Baasel dominates the high-end marking applications market in the region for semiconductor, electronics, and medical industries and supplies laser marking systems to several system integrators. Rofin high-power lasers are used in aerospace-component repair in Singapore and in automotive-component manufacturing in the region.

4. System integrators

Sintec Optronics is a manufacturer and supplier of industrial lasers expanded applications in cosmetics and medical fields, defence, industry and academic research. It is a system integrator, offering solutions in laser processing (cutting, welding and marking) by integrating lasers, mechanical parts, and optical components with computer control.  

Laser marking serial numbers and identifying marks on steel, plastic or any other material is simply done by altering the laser parameters based on what sort of material is being marked. These marks are permanent and cannot be smudged, erased or tampered with. Cutting of steel and sheet metal is made more productive upon the introduction of laser cutters. In addition to automated processing, factories would not have to keep replacing their blades and reduces machine maintenance. Sintec Optronics has recently worked with a company to automate their welding of a component by incorporating the use of a laser welder, allowing it to be mass produced 24/7. This was an improvement over using automated soldering rods that could not reproduce the quality of the weld.

In R&D, Sintec is jointly developing high power fiber lasers with an overseas collaborator to offer better competition in the fiber laser market. Fig. 3 is the fiber laser cutting and marking system from Sintec Optronics.

A more conventional laser system integrator is Resem Technologies, which specializes in stencil-cutting systems, glovebox welders, and precision multiaxis welding systems. Derrick Poh, managing director, emphasized that the Resem system has been able to attract the major stencil makers because of its high speed and hole roundness. Resem sells mainly to companies in Singapore, China, India, Japan, and Southeast Asia. It has been successful in placing its high-value glovobox welders to manufacturers of microwave and telecommunications devices. Resem has more than 50 cutting and welding systems in the field.

Precision Laser Solutions Pte Ltd (PLS) was registered in Singapore on June 11, 2009. It is founded with a core technical group of the former high tech local company, LaserResearch, specialized in precision laser material processing for HDD media. PLS is also focusing the teams’ competitive edges in developing innovative and high precision laser material processing solutions, which includes high precision laser solution development, team work and a smooth supply chain and cooperation with other automation players to develop the complex applications to best fit end customers requirement. The product including 3D robotic laser machine, laser texturing machine, laser weld inspection system, nanoscale laser index marking, etc. as shown in Fig. 4.

Manufacturing integration technology (MiT) specializes in contract equipment manufacturing for a wide range of industries such as semiconductors, storage media, and displays.
IDI Laser Services Pte Ltd, established in 1999, is the leading integrator and producer of Laser Systems in South East Asia. Designing with the customer’s thinking as the primary focus, IDI has been able to keep abreast of new trends and developments in the emerging and rapidly growing Laser Industry. IDI boast features such as customisable laser design and fast response time for the product support. We provide full turnkey solution to customer worldwide. Exporting to over 15 countries globally, IDI has established as the ideal brand for customers and distributors alike who are searching for the reliable and affordable laser integration company, without compromising on both the quality and the reliability. Today, IDI is distinctive for its development of laser machines, quick translation of technical concepts into user-oriented innovations, high standards of quality and reliable customer service.

Most of system integrators, such as PLS, MIT and IDI, supply high-value laser processing systems for the electronics and semiconductor industry, such as laser mark ICs, laser scribing and drilling on wafers. Most of these companies sell their systems worldwide to semiconductor manufacturers. MIT is an automation systems manufacturer focused on the semiconductor sector.

Besides the material processing, there are some other companies developed laser inspection system for electronics and semiconductor industries. KLA-Tencor is one of the biggest company which developed and manufacturing the laser inspection system for wafers.

5. End users

Many of the laser users in Singapore are metalworking companies producing high-value systems for the disk-drive and electronics industries. ETLA builds systems to assemble and test disk drives for multinational disk-drive manufacturers, other high-value system housings, and equipment for the semiconductor and medical industries.

The company started as a metal-fabrication shop. It has grown into a full contract equipment manufacturer with a metalworking facility that uses 4-kW laser cutting systems from TRUMPF to cut different sizes of stainless-steel panels for equipment housings. Nesting software minimizes scrap, and several shifts per day ensures adequate throughput.

Conventional manual welding is still used to join the housing components. Some of the companies have already been utilizing flexible laser welding and laser hybrid welding to increase weld quality and throughput. Because one of the benefits of laser welding is high speed for mass production.

Singapore has growing pharmaceutical and medical-instrument industries. Laser marking is used by many companies to mark packaging for pharmaceutical products. Plastic and foil surfaces are the major materials marked. Siemens Medical Instruments, one of the biggest hearing-instrument manufacturers, primarily uses lasers to mark hearing aids. Laser marking has mostly replaced pad printing with its flexibility, permanence of marking, and tamper-proof properties. The Singapore plant also uses lasers for stripping the miniature wires used in the hearing aid devices. Laser can also be used for medical applications, such as cosmetic surgery, eye surgery (LASIK), laser scalpel, etc.

There is a thriving aerospace maintenance repair and overhaul industry. Many companies participate in this sector, and several use high-power lasers for cladding and heat treatment in the repair of aerospace turbine engine components. Laser drilling is also used in the manufacture of some components.

Lasers play a significant role in the manufacture of high-value products in Singapore. Although low-power lasers for marking dominates, there are many multi-kilowatt CO₂ lasers used for cutting. Other applications in cladding, heat treatment, and welding are growing in importance. The conventional American opinion of job and factory loss to low-cost-labour countries such as China is contradicted in Singapore. Singapore has one of the highest labour costs in the region, but its factories making high-value products with the aid of laser processing are competitive worldwide.

6. Conclusion and future directions

This paper reviews the laser related activities in Singapore institute and companies. Most of the research work are carried out in the research institute. The companies normally involve in the laser related system manufacturing, integration and applications. Many laser systems are used for material processing, metrology and medical instrument.

However the laser market and application are quite mature nowadays, ultrafast laser applications play an important role in the ultra-precision engineering and scientific research areas. It is a very useful tool for ultra-precision material processing and other application currently because of its unique characteristic of interaction with materials. However the application is on the expense of low machining speed and high cost of in-
vestments. Future development for the ultrafast laser system will focusing on scaling the output power of picosecond laser to over 100 W, extending system lifetime, improving the stability and new development of fiber amplifier for high energy output.

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