CHAPTER 1

INTRODUCTION

1.1 LASER MARKING SYSTEMS

As laser technology matures, it is rapidly making inroads into many industrial applications. Laser-based marking systems have long been associated with high precision, speed and flexibility. They are used in a wide variety of industries for different applications.

Conventional marking system uses impact dot-matrix or ink jet for printing batch codes, serial numbers and expiry dates of finished products. Engravers made of metal or diamond are used to engrave as well as to scribe on hard surfaces. Milling bits are used in conjunction with CNC machines to produce 2-D or 3-D markings. Other systems that use silk-screen printing or hot stamping with metal templates are static in nature. For very fine and detailed markings, expensive photolithographic techniques are used.

Although relatively new, laser markers are steadily replacing conventional methods. Laser marking is exciting since as a non-contact process, there is no tool wear and the materials will not deform due to the force exerted by the marking tools. Furthermore, users do not have to worry about refill of inks or ribbons, which can be a messy affair. Worn off tools are more difficult to detect but will produce inferior marking or bad scribing lines that lead to wastage of materials. Scanner-based laser markers offer serialisation or personalisation where serial numbers or custom logos can be created easily.

Another important advantage of laser marking is that it can be used in a clean room environment. Non-ablative marking process ensures that there will not be any material removal, which even in minute quantities can be a serious source of contamination. This characteristic is exploited in semiconductor and electronics industries, where laser markers are used for marking batch or trace codes on silicon wafers and harddisk substrates. Laser beam melts the substrate, which will subsequently resolidify or recrystalise, forming visible marks.

Laser marking has been used in the high-volume manufacturing industry for products such as flexible interconnects, wires, keyboards, bottles and packaging materials such as carton boxes. Laser marking systems are not only being used as tools to insert product identity markings but used for a host of other diverse applications. It is a versatile instrument that can perform multiple functions such as cutting, engraving, and has been proven particularly useful in scribing. It has been successfully used in manufacturing rubber stamps. Both positive (raised marks) and negative (indented marks) type of stamps can be produced by using lasers to vaporise unwanted areas. Once the required pattern is etched, the marker can automatically cut out the stamp to required size. In scribing application, a carefully controlled laser beam is scanned across the material to deliberately create a line of weakness along the surface of a material prior to breaking that material along the line. It is used in dicing silicon wafers and scribing LCD glass panels.

New imaginative use of laser markers opens up a range of new exotic applications that is previously either too costly, difficult or outright impossible to achieve. An example is marking 3-D images in solid glass. On top of scanning in the XY position, a third axis that varies the focus point of a high power laser is used to form micro-bubbles in the solid glass. Another creative use of laser marker is rapid prototyping. Here, 3-D computer model is horizontally sliced into stacks of 2-D cross sections. Each 2-D cross-section is marked on top of a polymer bath, one layer at a time. The laser beam hardens the top layer of the photocurable polymer bath. Subsequent layers are formed by lowering the platform in small steps and the process is repeated until a solid 3-D polymer model is formed. Even a transparent and hard material such as diamond can be engraved with security micro marking that is normally invisible to human eyes. High-end products such as expensive spectacle lenses and other products can be value-added by allowing personal markings.

Basically, there are two methods of obtaining the required pattern. One method is to scan the laser beam across the surface using computer-controlled mirrors so that the pattern is traced out directly on the surface. This method is very versatile and can provide serialised markings but it is slower and requires high capital outlay. To improve marking speed, some markers offer on-the-fly marking, where materials are continuously fed and the scanning beam tracks the motion of the materials on conveyor. The other approach is to use a reflective or through mask with the required pattern cut out of it. The mask is placed over the surface, which is then irradiated with the high-powered pulsed laser beam. Because the whole design is marked in a single pulse, it is a very high speed and comparatively economical technique.

1.2 APPLICATION IN FILM SUBTITLING INDUSTRY

In many countries, foreign films brought into the country are required to be subtitled in local languages. Usually two to three lines of local language translations are printed at the lower portion of the film to help audiences understand the dialogues of the movies. Many countries have made it a legal requirement but some countries simply provide film subtitles to benefit the general audiences. Recent high-tech developments in the movie industry have resulted in high quality film, special visual and sound effects, high quality projectors and sound system housed in acoustically designed cinema. These improvements have fuelled the demand for high quality subtitles to be printed on motion picture films. Conventional methods often produce inconsistent and jittery characters. This demand has opened up a new application for laser marking system. Laser markers offer the advantages:

i. Precise amount of laser energy can be delivered by high precision scanners ensuring consistent quality.

ii. No water or chemicals that will leave visible residual marks are used as opposed to the conventional method.

iii. Overall time saving because subtitles can be instantly generated by computer and process automation that reduces labour requirements. Because of the automated process, less manual film handling minimises the risk of scratches that degrades the film quality.

1.3 CONVENTIONAL HOT-STAMPED FILM MARKING PROCESS

Conventional film marking process uses copper templates. Subtitles are etched onto the copper template using wet chemical etching process similar to the production of printed circuit boards. Films to be etched are softened with photographic wetting agent before they are stamped with heated copper templates. Other method uses hot wax instead of wetting agent.

Using this method, the quality of the subtitles stamped on film depends largely on the quality of the template used. The small character size (1 mm in height with line thickness of 80 microns) makes it difficult to produce a good template. Small imperfections in the template cause discernible character defects when projected on the screen because they are magnified about 200 times. Furthermore, for smooth flicker-free viewing, 25 film frames must be projected every second. This requires precise repetition of the subtitles in the same location to avoid character jittering. Due to the inconsistency in clamping films and templates steadily as well as the heavy demands on the precision positioning motion of the stamper, jittering and drifting of the subtitles often result. Typically, there are at least 1000 subtitles for every movie. Management of the large number of templates is difficult, as they have to be sorted by sequence and changed every time new subtitles need to be stamped. Chemicals used in the template production leads to disposal problem. As a result, chemical-etching process is being phasing out gradually.

1.4 OBJECTIVES OF THIS STUDY

This project started in collaboration with the local film subtitling industry to study the viability of developing a laser marking system to etch subtitles on film. Laser film marking system has the potential to offer improvements of quality, precision and process automation that can overcome limitations posed by the current chemical and mechanical etching process. Consequently, the main objectives of this project are:

1. Investigate laser film marking process and mechanism. The key issue in building a successful marking system is to understand the interaction between the laser beam and film material. This study involves the investigation of the effects of using two different laser sources, Argon Ion and Copper Vapour Lasers (CVL), on two different film materials, namely Polyester and Triacetate.

2. Construct a galvanometer-based laser marking system.

3. Construct a CVL system as the laser source for the laser marking system.

4. Characterise the laser marking by quantitative and qualitative methods, investigate the process parameters, and limiting factors.

1.5 OUTLINE OF THE CHAPTERS

This thesis is presented in five chapters. The second chapter reviews the laser marking process and the film material under study. An overview and rationale behind the selection of laser sources and laser scanning systems are also presented here. Chapter 3 describes the design and construction of the laser marking system including the copper vapour laser. Measurement and analysis tools applied to the marking results are also presented here. Chapter 4 presents qualitative and quantitative analyses of the laser marking results. Chapter 5 presents the conclusion and suggestions for future work.