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Laser Cutting and Piercing of Thin Films and Flexible Substrates

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Abstract

The processing of thin films and flexible substrates often makes use of lasers for a variety of tasks, including cutting and piercing. The production of delicate patterns, holes, and forms in a number of materials, such as metals, polymers, and ceramics, is made possible via the use of these technologies, which provide accurate and time-efficient processes. Since lasers are capable of cutting and penetrating materials with thicknesses ranging from a few microns to several millimetres, they are well suited for use in microfabrication, electronics, and biomedical engineering applications. The process of laser cutting involves directing a high-powered laser beam onto the material, which then melts or vaporises the region of interest in the material. This procedure is handled by a computer-aided design (CAD) system, which enables accurate placement of the laser beam as well as the shape of it. The usage of laser cutting is especially beneficial when it comes to the production of intricate and detailed forms, as well as the creation of tiny elements with high aspect ratios. In the process of laser piercing, the laser beam is concentrated on a single location in order to make a tiny hole in the material. The material will melt and evaporate as a result of the heat created by the laser, which will result in the creation of a hole with a diameter of only a few microns. Both the drilling of holes in electronic components and the creation of vias in printed circuit boards are common applications for the technique of laser piercing. The fact that laser cutting and piercing are non-contact processes removes the need of coming into direct physical touch with the item being worked on, which in turn lowers the likelihood that the material may be harmed or contaminated. In addition, these procedures are ideal for large-volume production operations because to their high level of accuracy as well as their high rate of speed. However, the thickness of the material being processed, the characteristics of the material being processed, and the cost of the laser equipment may all act as potential limitations for laser cutting and piercing.

Keywords: Laser cutting, Laser piercing, Thin films, Flexible substrates, Microfabrication, CAD system, High precision non-contact

Introduction

The slicing and perforating capabilities of lasers have fundamentally altered the manner in which we treat materials, particularly thin films and flexible substrates. These methods use the employment of a powerful laser beam in order to accurately cut or penetrate the material. As a result, they are both very effective and accurate. This degree of accuracy is absolutely necessary in a wide variety of fields, including microfabrication, electronics, and biomedical engineering, all of which involve the production of tiny, delicate components. The fact that laser cutting and piercing do not need physical touch is one of the most significant benefits offered by these processes. Because of this, there is no physical contact between the laser and the substance that is being treated, which eliminates the possibility of causing harm or contaminating the material. In addition, the process is highly automated, with control being provided by a computer-aided design (CAD) system. This provides the ability to position and shape the laser beam with pinpoint accuracy. Laser cutting and piercing are two processes that are very helpful when it comes to the creation of intricate and detailed designs, as well as little features with high aspect ratios. As a result of the fact that they are suitable for use on materials varying in thickness from a few microns to several millimetres, they are well suited for a diverse array of applications. “For example,

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laser piercing may be used to drill tiny holes in electronic components, while laser cutting can be used to produce elaborate designs on printed circuit boards. Both processes can be utilised to generate complicated patterns.

Laser cutting and piercing both offer a number of benefits, but they also have a number of drawbacks. The quality of the cut or puncture that is produced by a laser may be negatively impacted by factors such as the thickness and characteristics of the material that is being treated, and the expense of the laser equipment may make some applications unfeasible. However, as technological development continues, it is expected that these strategies will become easier to implement and will be used in a variety of contexts more often. Processing thin films and flexible substrates may be done in a manner that is both extremely accurate and very efficient with the help of laser cutting and piercing. Because of their non-contact nature, high level of automation, and capacity to manufacture complicated forms and features, they are crucial tools for a variety of sectors, ranging from biomedical engineering to microfabrication. Both laser cutting and laser piercing are very adaptable processes that may be used with a broad variety of materials, such as metals, polymers, and ceramics. Processing thin films and flexible substrates, both of which may be challenging to deal with when using typical cutting processes, is a particularly effective use for these tools.

In the field of microfabrication, laser cutting and piercing are crucial processes for the production of very minute components that meet the highest standards of precision and accuracy. They are used for a variety of tasks, including the creation of detailed patterns in microelectronic devices, the drilling of holes and creation of vias in printed circuit boards, and so on. Lasers may be used for cutting and piercing in the field of biomedical engineering, which enables the creation of complex microfluidic channels that can be utilised for medication delivery and other purposes. The speed at which lasers may pierce and cut is another another benefit offered by these machines. They are able to process materials at a pace that is far quicker than the conventional ways of cutting, which enables them to be an excellent choice for high-volume production applications. Additionally, the use of a CAD system enables quick prototyping in addition to design iteration, both of which may assist minimise the amount of time and money required to bring new goods to market. Laser cutting and piercing both offer a number of benefits, but they do have a few drawbacks as well. They are most useful for working with materials that are thin, and the price of the necessary laser equipment might be prohibitive for some applications. Additionally, heat is produced as a byproduct of the operation, and this heat has the potential to adversely affect the substance that is being processed. These concerns, however, may be reduced to a tolerable level by adequate management and calibration. Processing thin films and flexible substrates may be accomplished with the assistance of strong equipment like laser cutting and piercing. Because of their capacity to generate accurate forms and features rapidly and effectively, they are indispensable in a broad variety of sectors, including microfabrication, electronics engineering, and biomedical engineering, to name just a few. As the state of technology continues to improve, we can anticipate that the aforementioned methods will continue to gain popularity and become easier to access.

Laser Cutting of Flexible Glass

Laser Ablation Technique

We explored the use of long-pulse and short-pulse lasers to cut Willow Glass. Both types of lasers are considered to be pulsed. Both the nanosecond 355 nm laser and the 266 nm laser that were used in the study ablate glass through linear absorption. The femtosecond 780 nm laser that was also used in the study interacts with glass through nonlinear absorption. The long-pulse lasers that were used in the study include a nanosecond 355 nm laser and a 266 nm laser. A convex lens element or a microscope objective was used in order to concentrate a laser beam from one of the pulsed lasers on the surface of

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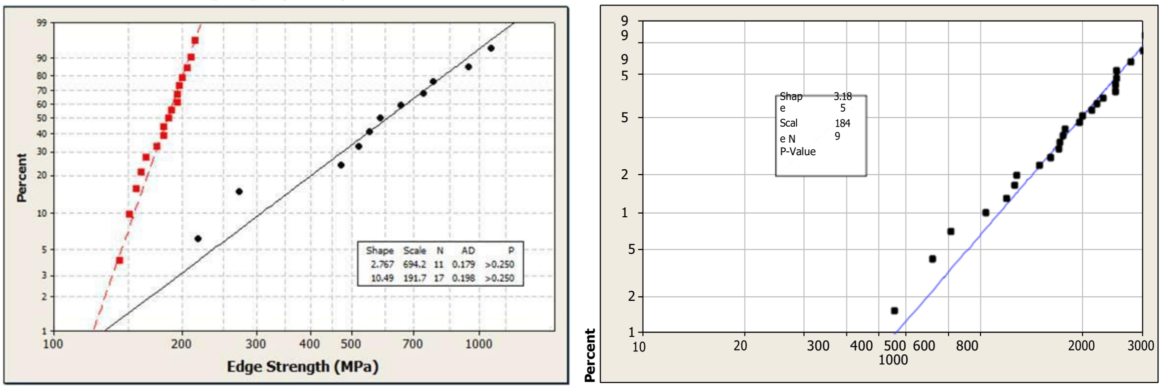
the glass. The procedure of laser ablation resulted in the formation of a shallow groove on the glass. The cutting line was denoted by the grove that was ablated. After that, mechanical separation along the groove was used to separate the glass. The two-point bend technique was used to produce and analyse samples with dimensions of 20 millimetres by one hundred millimetres". The samples were split up into two distinct categories. In one set of tests, the sample was examined with the laser incident side under tension, while in another set of tests, the laser side was examined with the side under compression. In, we present a typical strength distribution from samples cut with the nanosecond 266 nm. This distribution shows that the two sample groups exhibit different strength distributions due to the nature of the two-step process, with the laser incident side displaying a weaker strength than the other sides. The strength distributions of samples that were tested after being produced with either long or short laser pulses were found to be comparable.

Laser Crack Propagation Technique

The method known as laser crack propagation works by applying tensile stress produced by a laser to fragile materials like glass in order to spread an existing fracture. The glass sheet is quickly heated by the laser beam to a temperature that is above the softening point but below the strain point. The cooling that comes after the heating is called quenching. "The act of heating the glass and then allowing it to cool provides the tensile tension that is necessary for an existing crack in the glass to spread. In this particular kind of cutting, CO2 lasers are the tool of choice. After heating with a CO2 laser, the ultrathin glass substrates used to make Willow Glass just need to be cooled to room temperature for a through-crack to continue propagating.



a) b)

Source : Weibull strength distributions of Willow Glass cut with different processes. a) Laser ablation process with a nanosecond 266 nm laser; b) Laser crack propagation process with a CO2 laser

Gaseous emissions

Online measurements of carbon monoxide were taken for each possible combination of joining. In addition, the total gaseous hydrocarbon content was determined on-line by the use of a flame ionisation detector (FID) in the case of metals that had an organic coating. In order to conduct a more accurate analysis of organic compounds, only very tiny portions of the gas stream were passed through sample filters that were equipped with the necessary adsorption materials. These samples were evaluated by GC-MS to determine the levels of polar and non-polar hydrocarbons, as well as HPLC to determine the levels of aldehydes and ketones. The GC-MS samples were subjected to a quantitative analysis with regard to the principal components of benzene, toluene, ethylbenzene, and xylene. In addition to this, a qualitative analysis of the GC-MS spectra was performed with relation to the other components (assignment of retention time peaks)

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Metering box (including probes), tube diameter 100 m

- Laser cutting and piercing can be used with a wide range of lasers, including CO2, Nd:YAG, and fiber lasers. Each type of laser has its own strengths and limitations, which can affect the choice of laser for a given application.
- In addition to cutting and piercing, lasers can also be used for other types of material processing, such as welding, marking, and engraving.
- Laser cutting and piercing can produce extremely small features, with typical spot sizes ranging from a few microns to a few hundred microns. This makes them well-suited for applications where high precision is required.
- The use of a CAD system allows for complex designs and shapes to be easily produced, and for changes to be made quickly and easily.
- Laser cutting and piercing can be used to produce parts and components in a wide range of industries, including aerospace, automotive, medical, and consumer electronics.
- While laser cutting and piercing are typically used for thin films and flexible substrates, they can also be used on thicker materials, albeit with reduced precision and speed.
- The cost of laser cutting and piercing equipment can vary widely depending on the type of laser and the specific application. However, the cost is generally higher than that of traditional cutting methods.
- Laser cutting and piercing can be performed in a variety of environments, including clean rooms and manufacturing facilities. However, safety measures must be taken to prevent eye damage and other hazards associated with high-powered lasers".
- While laser cutting and piercing offer many advantages, they are not always the best option for every application. Other cutting methods, such as waterjet cutting and die cutting, may be more suitable depending on the material and the specific requirements of the project.

conclusion

Laser cutting and piercing of thin films and flexible substrates provide accurate and effective ways for manufacturing intricate forms and patterns in a broad variety of materials. These processes may be used to create intricate shapes and patterns. The processing of materials has been fundamentally altered as a result of the development of these methods, notably in the fields of microfabrication, electronics, and biomedical engineering. The fact that laser cutting and piercing are non-contact processes, which removes the chance of the material being treated being damaged or contaminated, is one of the most significant benefits of using these techniques. In addition, the use of a CAD system enables exact placement and shape of the laser beam, which is vital for developing features that are microscopic and detailed. When it comes to the creation of intricate forms and patterns in materials with thicknesses ranging from a few microns to several millimetres, laser cutting and piercing are two processes that are especially beneficial. As a result of their rapidity and level of automation, they are also well suited for use in high-volume production applications. Laser cutting and piercing both offer a number of benefits, but they also have some drawbacks, such as the high cost of the necessary equipment and the risk of causing heat damage to the material that is being treated by the laser. These concerns, however, may be reduced to a tolerable level by adequate management and calibration. Cutting and piercing thin films and flexible substrates with a laser are key tools for many different sectors because they provide a high level of accuracy and efficiency for a diverse selection of uses. These methods are expected to become increasingly more commonly utilised and accessible as technology continues to improve, clearing the way for new advancements in the fields of microfabrication, electronics, and biomedical engineering. We may expect to see this happen in the near future.

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