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"INVESTIGATING THE SETTINGS OF FIBER LASER MACHINE TO MARK BLACK ACRYLIC"

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1 ABSTRUCT

The experiment based on marking black acrylic sheet using fiber laser Marking machine , We will investigate the Quality of the marking results wile we are changing the machine setting to conclude the best setting of marking 3mm black Acrylic sheet .

2 Introduction

Fiber lasers operate on the physics principles as lasers but they possess unique characteristics that set them apart and make them highly practical.

If you've ever observed a laser pointer projecting a spot onto a surface you'll notice that the appearance of a laser beam is distinct, from anything. Laser beams typically exhibit the following traits:

- very collimated- the beam is near straight
- single frequency or color
- Coherent / in phase - all the waves are going up and down at the same time

Simply put the laser beam travels in a direction emitting light of a color with all photons synchronized. In contrast regular light, from a bulb consists of colors and scatters in all directions. While you can somewhat focus light laser light offers capabilities that 'normal' light cannot match.

3 First Principle

The Word laser means , for Light Amplification by Stimulated Emission of Radiation.
The concept of amplification essentially refers to increasing the intensity of light to how an audio amplifier boosts the volume of sound. Within this context "stimulated emission" carries a significance, for scientists relating to the process through which light is generated. To grasp this concept fully it's essential to have an understanding of atoms. Atoms consist of electrons revolving around a nucleus. These electrons typically occupy a low energy orbit known as the "ground state." When provided with energy they can transition to a higher energy orbit referred to as an " state."
For various reasons to do with quantum mechanics, they can only sit in very specific orbits around the atom. These specific orbits are set by the properties of the elements used, so generally speaking they can't be changed. For example, gold has one set of orbits, oxygen another, and sodium yet more. Each is very different, and so only some are useful for what we want to do. (Figure 1)

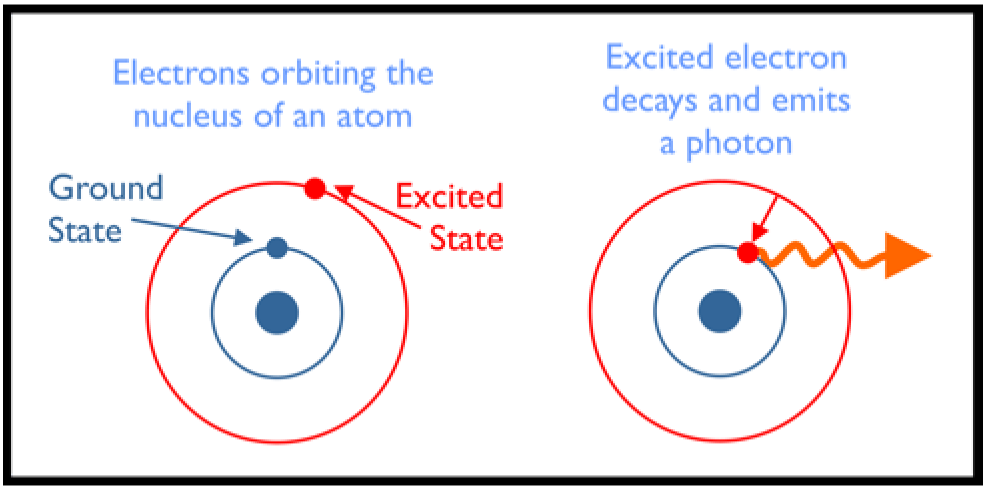

Figure 1

When an electron is in a higher orbit, an excited state, it wants to return to the ground state - a process called 'decay'. To do so, it needs to lose energy, and this often happens by giving off a photon - in other words emitting light.

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To get the electron to the higher state, the same process happens in reverse. An electron absorbs a photon to move it to a higher level. For this to happen, the energy in that photon needs to match what's required to raise the electron to that orbit. If the passing photon has the wrong amount of energy, nothing happens. As we've indicated before, the amount required is dependent on the type of material used.

Once an electron is sitting in a higher state, it will remain there for a period of time, and then naturally decay back to the ground state. That's just 'emission', rather than 'stimulated emission', so not what we want exactly. When a photon of the same frequency passes by, it encourages the electron to decay right at that point, producing another photon that looks almost exactly the same as the first one: that's stimulated emission.

The frequency (or color) of a photon is dependent on how much energy it is given, so if all the photons are given the same energy they are all the same color. This means that for a particular material, whenever this happens to an atom they all give off light of the same color.

However, electrons being 'excited' to a higher state and dropping down gain doesn't happen naturally, at least not often enough to notice, so we need to make it happen.

The way practical lasers work is this:

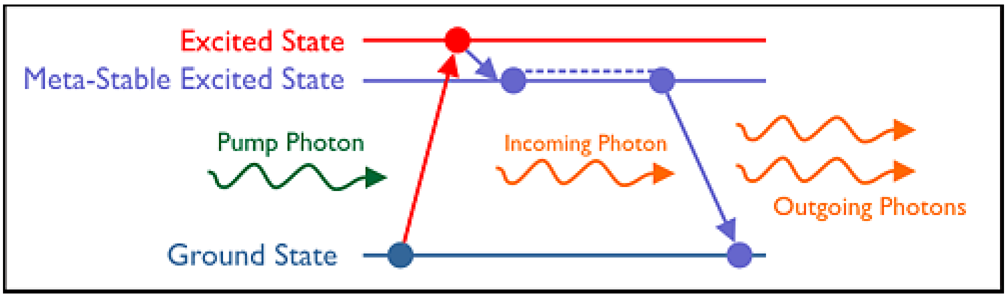

Figure2

First, we push electrons up into a higher orbit (this is called pumping). This can be done in several ways, but a common way is to bombard the atoms with light to raise the electrons. (Figure 2)

In most cases, the electron is in an unstable state, and it will quickly move to a lower state. We need it in a meta-stable state for our purposes. Meta-stable means that the electron will hang around for a little while before going back to the ground state.

Laser material has to have a meta-stable state corresponding to a useful energy. In laser material, very soon after we 'pump' the electron to a higher state, it slides down to a slightly lower meta-stable state. Now we have a lot of electrons hanging around with the right amount of energy, waiting to be stimulated into giving that energy up in the form of a photon.

All it takes is for one of the electrons to drop down and emit a photon. This will start a cascade. When that photon passes by another electron in the meta-stable state, it encourages it to drop down and emit another photon. Now we have two photons, each of which can go on to encourage two more electrons to emit, so we have four photons, and so on until we get a very large number of photons. This is 'stimulated emission', as the photons are stimulating the electrons to emit more photons.

Because of the way the photons encourage one another into existence, they are all the same color, and they are all in step with one another. Now we have an army of photons marching in step together, something you don't find in nature.

If at this point all the photons rush out of the material, it doesn't work terribly well. We need to keep on 'pumping' the electrons back up so they are ready to emit photons, and we need to keep the photons zipping backwards and forwards to encourage even more to come out.

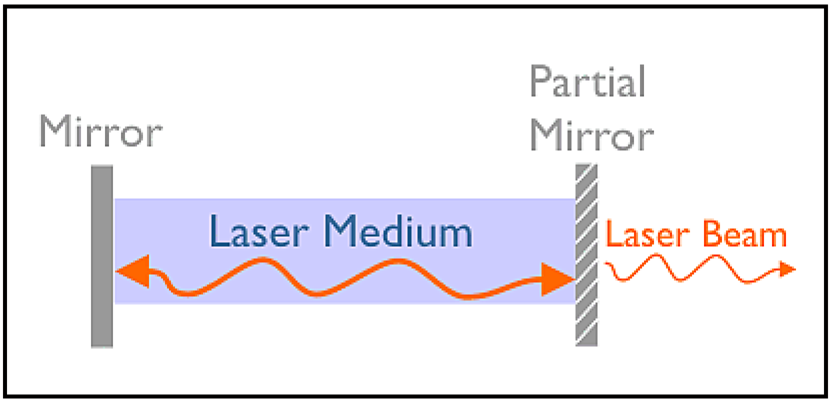

Figure 3

The way we do this is by putting two mirrors in place at either end of the material (called the 'laser medium'). This creates what is called the 'laser cavity'. The mirrors reflect the light backwards and forwards, and on every round trip, more and more photons are generated. (Figure 3)
The newly-created laser light needs to be let out in order to be useful, so one of the mirrors doesn't reflect everything. Instead, it lets a tiny percentage of the light out, and that is our laser beam.

What is fiber laser :

A fiber laser is a type of laser where the active gain medium is an optical fiber doped with rare-earth elements like erbium, ytterbium, neodymium, dysprosium, praseodymium, and thulium. This active fiber is designed to amplify light. The term 'fiber' refers to the light's path, which, unlike in traditional lasers, is confined within a fiber optic cable.

The Basics of Fiber Laser Operation

In a fiber laser, the beam is generated by the rare-earth-doped fiber and is guided to the workpiece via the fiber optic cable. This differs from traditional lasers, where the beam is directed towards the workpiece using mirrors.

Types of Fiber Lasers

- **Continuous Wave (CW) Fiber Lasers:** These lasers emit a continuous laser beam, making them ideal for applications like cutting, welding, and drilling.
- **Pulsed Fiber Lasers:** These lasers emit pulses of light and are typically used in marking and engraving applications.
- **Ultrafast Fiber Lasers:** These lasers have incredibly short pulse durations (in the picosecond or femtosecond range). They're used in highly precise applications like micro-machining, medical surgery, and research.

4 Study results Comparison

Before we go through our study results there are some points needs to be mentioned to clarify our study and results :

A. Engraving marking result will be expressed by either :

- **Good**: means that you can see the marking on the acrylic piece but its not Obvious and have marking scratches .
- **Verry good**: means that you can see the marking on the acrylic piece and its Obvious but it have slight marking scratches .
- **Excellent:** means that you can see the marking on the acrylic piece and its Obvious and without any marking scratches .

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B. Fiber laser marking machine Specifications:

- Laser wavelength:1064nm
- Laser power: 20w
- Modulation frequency:20KHz-80KHz
- Scanning speed:≤7000mm/s
- Repeatability precision:0.001mm
- Engraving range:110mmX110mm(optional)
- Marking depth: 0.01-0.2 mm (Depending on the material)
- Marking line width: 0.01-0.2 mm (Depending on the material)
- Power supply: AC220V ±10%, 50 Hz ≤0.5KW

Table 1 : Machine Power Setting to 10 Watts

W	Machine Settings			Result	
	Power Watts	Speed (mm/Second)	No.Off loobs	Marking Color	Marking Result
1	10	400	1	Gray	Good
2	10	350	1	Gray	Good
3	10	300	1	Gray	Good
4	10	250	1	Gray	Good
5	10	200	1	Gray	Good
6	10	150	1	Gray	Good
7	10	400	2	Gray	Good
8	10	350	2	Gray	Good
9	10	300	2	Gray	Good
10	10	250	2	Gray	Good
11	10	200	2	Gray	Good
12	10	150	2	Gray	Verry Good

- **Good**: means that you can see the marking on the acrylic piece but its not Obvious and have marking scratches .
- **Verry good**: means that you can see the marking on the acrylic piece and its Obvious but it have slight marking scratches .
- **Excellent:** means that you can see the marking on the acrylic piece and its Obvious and without any marking scratches

Table 2 : Machine Power Setting to 14 Watts

No.	Machine Settings			Result	
	Power Watts	Speed (mm/Second)	No.Off loobs	Marking Color	Marking Result
1	14	400	1	Gray	Good
2	14	350	1	Gray	Good
3	14	300	1	Gray	Good
4	14	250	1	Gray	Good
5	14	200	1	Silver	Good
6	14	150	1	Silver	Good
7	14	400	2	Silver	Good
8	14	350	2	Silver	Good
9	14	300	2	Silver	Good
10	14	250	2	Silver	Very Good
11	14	200	2	Silver	Very Good
12	14	150	2	Silver	Very Good

- **Good:** means that you can see the marking on the acrylic piece but its not Obvious and have marking scratches .
- **Verry good**: means that you can see the marking on the acrylic piece and its Obvious but it have slight marking scratches .
- **Excellent:** means that you can see the marking on the acrylic piece and its Obvious and without any marking scratches

Table 3 : Machine Power Setting to 18 Watts					
No.	Machine Settings			Result	
	Power Watts	Speed (mm/Second)	No.Off loobs	Marking Color	Marking Result
1	18	400	1	Silver	Verry Good
2	18	350	1	Silver	Verry Good
3	18	300	1	Silver	Verry Good
4	18	250	1	Paiej	Verry Good
5	18	200	1	Paiej	Exelant
6	18	150	1	Paiej	Exelant
7	18	400	2	Paiej	Verry Good
8	18	350	2	Paiej	Verry Good
9	18	300	2	Paiej	Verry Good
10	18	250	2	Paiej	Verry Good
11	18	200	2	Paiej	Verry Good
12	18	150	2	Paiej	Verry Good

- **Good**: means that you can see the marking on the acrylic piece but its not Obvious and have marking scratches .
- **Verry good**: means that you can see the marking on the acrylic piece and its Obvious but it have slight marking scratches .
- **Excellent:** means that you can see the marking on the acrylic piece and its Obvious and without any marking scratches

5.Discussion

Using a fiber laser marking machine on a black acrylic piece generally results in a precise, high-contrast mark. Here's what you can expect:

- **Marking Process**: The fiber laser emits a high-intensity beam of light that interacts with the surface of the black acrylic. The energy from the laser causes localized heating, which can lead to a variety of effects such as engraving, surface alteration, or color change, depending on the laser settings.
- **Engraving**: One common result is engraving, where the laser ablates (removes) a thin layer of the acrylic material. This creates a depression or groove on the surface. The engraved area often appears lighter than the surrounding material, providing a good contrast against the black acrylic.
- **Surface Marking**: Depending on the settings (such as power, speed, and frequency), the laser can also alter the surface properties of the acrylic without significant material removal. This can create marks that might be slightly raised or textured compared to the untouched surface.

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- **<u>Contrast</u>**: On black acrylic, the contrast is typically high. The laser can produce marks that appear Paige , gray, or silver, depending on the exact interaction between the laser parameters and the material.

- **<u>Precision</u>**: Fiber lasers are known for their precision. They can produce very fine details, making them ideal for marking intricate designs, text, barcodes, or logos on acrylic.

- **<u>Durability</u>**: The marks made by a fiber laser on acrylic are generally durable and resistant to wear, as the process often involves altering the material itself rather than just applying a surface coating.

- **<u>Quality and Speed</u>**: Fiber lasers can produce high-quality marks at relatively high speeds, making them efficient for both prototyping and production environments.

In summary, using a fiber laser marking machine on a black acrylic piece results in precise, high-contrast marks that can range from fine engravings to subtle surface alterations, depending on the laser settings used.

6. Conclusion

Result of the study: The result of the study can be summarized as machine setting recommendations

No.	Machine Settings			Result	
	Power Watts	Speed (mm/Second)	No.Off loobs	Marking Color	Marking Result
5	18	200	1	Paiej	Exelant
6	18	150	1	Paiej	Exelant

Fiber lasers offer several advantages over traditional lasers. Let's explore some of these benefits:

- **High Efficiency:** The fibers laser machine have a higher working surface area coverage comparing with Co2 laser machines which make here faster to mark and engrave .

- **Reliability:** Fiber lasers have fewer moving parts and no alignment issues, leading to higher reliability and lower maintenance needs.

- **Beam Quality:** The design of fiber lasers allows for high beam quality, resulting in precise and high-quality work.

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References:

Clarke, S. (2023). Laser mastery: A comprehensive guide to the laser cutting and engraving [Kindle

Hatcher, B. (2021). Laser cutting fundamentals [Print replica, Kindle edition]. [ASIN: B08SBKWFGM].

Goodwin, E. (2021). The laser cutter handbook: A guide to machine setup, operation, servicing, and maintenance. Independently published. [ASIN: B09BY8434R].

"تحقيق إعدادات آلة الليزر الليفي لعلامة الأكريليك الأسود"

إعداد الباحث:

المهندس محمد العبد

الملخص:

تستند التجربة إلى وضع علامات على صفائح الأكريليك الأسود باستخدام آلة وضع العلامات بالليزر الليفي. سنحقق في جودة نتائج العلامات بينما نقوم بتغيير إعدادات الآلة لاستنتاج أفضل إعداد لعلامة صفائح الأكريليك الأسود بسمك 3 مم.