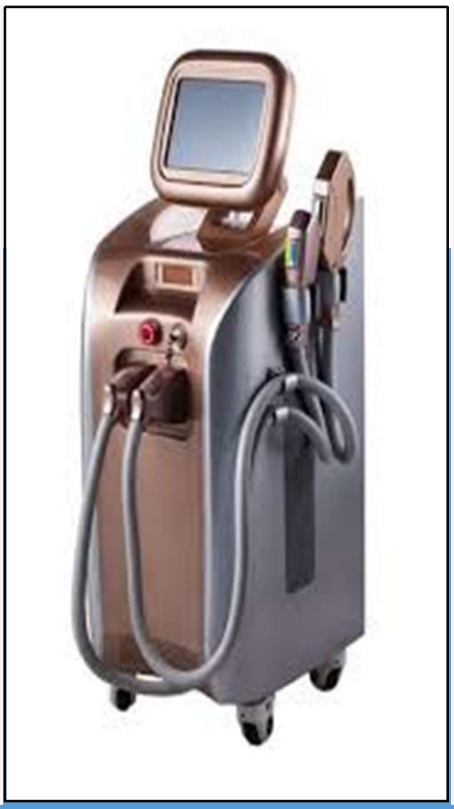
skinscience

# The Essence of Laser Hair Removal



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# Preface

This is a notes prepared by Laser sales and application Engineer, based on his 18 years of experience in sales and application training of various laser machines available in the market. This is not a book or journal, it is only an info notes prepared based on understanding the laser science from various company materials, books, research papers and also assumptions made from understanding. The examples given in these notes are just for understanding and not to give you any exact value. This has two sections, Section-1 is the basics of laser hair removal, the logic of the treatment parameter chart, and section 2 provides information on various technologies of hair removal with comparison, the Latest advancements in hair removal laser technology, treatment form, guidelines for choosing right laser parameter &guidelines to do good treatment, and also about guidelines to select best laser hair removal machine. All the information discussed is based on the machines/technologies available in the market, not based on any particular brand or Laser model. Under the topic of selection of laser hair removal machine, you may get guidelines in evaluating & choosing the right Laser machine that suits your requirement but it will not recommend or mention any particular brand or model. The reason is there is no machine in the world that would match all the requirement specifications of all the users, each user will have different requirement specification and criteria, hence market needs multiple Laser models/technology to suit different users requirement specifications. This material also wants to avoid giving biased information by mentioning brand /model names. Also, the model / brand which is top in specification today may not be in the top position forever, it will be replaced by newer / latest models in the future.

# SECTION - 1

## What is Laser hair removal?

The concept of hair removal was defined in 1998 by the US Food and Drug Administration ( FDA), which allowed some manufacturers of hair removal lasers and flash lamps used for Hair removal to use the term "permanent hair reduction". The agency defined permanent hair reduction means the "long-term, stable reduction in the number of hairs regrowing after a treatment regime." In other words, the number of hairs regrowing must be consistently greater than the duration of the complete growth cycle of hair follicles, which varies from four to twelve months by body location.

## How it works?

It works on the principle of Selective photothermolysis (photo derived from the greek word photo means light, thermo means heat, and lysis means disintegration of cell or destruction). The laser beam that is applied on the skin is selectively absorbed by the melanin in the hair follicle and is converted into heat, after absorption of the laser by the melanin in the hair follicle. This heat generated destroys the hair follicle. It is also absorbed by the melanin in Epidermis, let's see in the next topic how it destroys only hair roots without damaging the epidermis.

## Science of Laser Hair Removal:

Following physics are involved in the process of laser hair removal Mechanism.

**Laser tissue interaction:** When you apply a laser beam on human tissue, the incident laser beam can get reflected, scattered, transmitted, and absorbed. We need the majority of laser beam to get absorbed by the target (eg. melanin) to do the desired treatment. Following figure .1 shows different laser tissue interaction.

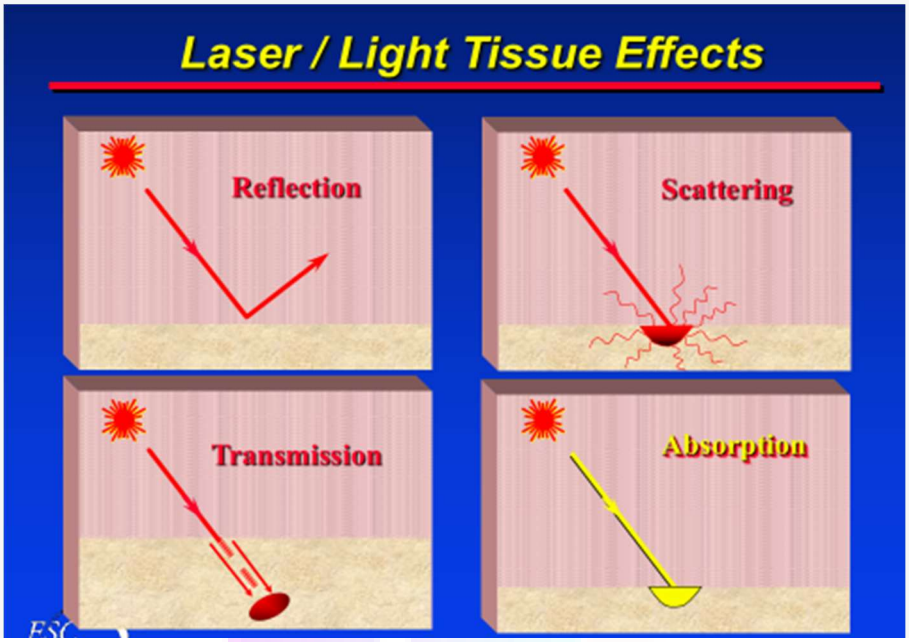



*Figure 1*

**Laser Chromophore:** Chromophore is nothing but when you apply a laser beam on human tissue, the component in the tissue that absorbs the major amount of laser beam. Example. If you apply a diode laser on the skin, the majority of the laser beam is absorbed by the melanin in the skin and hair, so the chromophore of the Diode laser is melanin. This characteristic plays a very important role in laser hair removal.

This chromophore level of absorption varies from laser to laser. Eg. Melanin ( chromophore) absorption in the diode is more compared to Nd:yag laser. Following figure 2 shows the graph of melanin absorption in different types of laser. The Chromophore of a laser can also be different or be the same from laser to laser.

Diode and Nd:yag laser have the same chromophore melanin, but for KTP and 585nm pulse dye laser chromophore is hemoglobin. Based on the chromophore application of the laser changes.

(We saw that each laser has a specific chromophore, which absorbs most of the laser beam. Chromophores are like melanin, hemoglobin, water etc. When the laser is passed how does it identifies the melanin, haemoglobin and gets absorbed ( most of the beam ) only in the chromophore ? Actually laser cannot identify which is melanin or haemoglobin in the tissue when passed, it can identify the chromophore only based on the colour. This means the laser that has melanin chromophore are absorbed by the black or dark colour, apart from melanin any other substance in the tissue that is black color will absorb most of the laser. Hence while doing laser hair removal procedure we should not mark the treatment area with black or dark color pencil or markers. Similarly, a laser with chromophore as haemoglobin will be absorbed by Red colour substance.

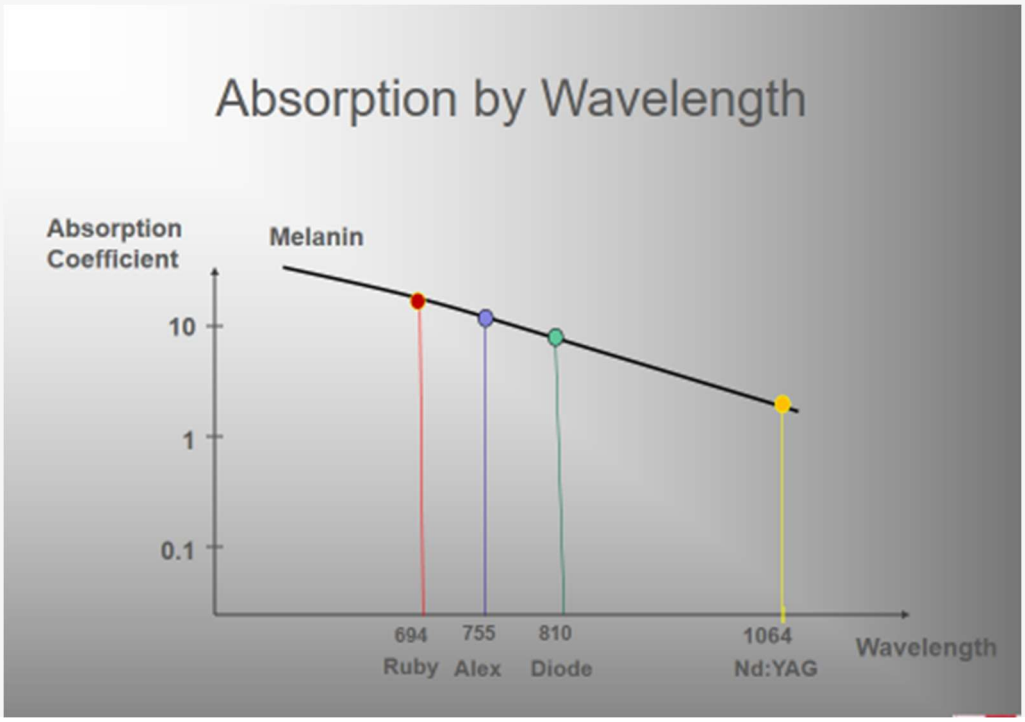


Figure 2

In the above figure you can see the melanin absorption graph, where the Ruby laser has highest melanin absorption, next comes alexandrite and then diode and Nd:yag. Since Nd:yag laser has the lowest melanin absorption, the Nd:yag laser manufacturing company claims that it is safe for dark skin hair removal treatment.

**Thermal relaxation time (TRT):** when you apply laser to a tissue it is absorbed by target like hair follicle (chromophore melanin) and then converted to heat to perform the treatment. After absorption by chromophore the heat generated can be transmitted to surrounding tissue which is not our target of treatment. This heat generated is not transmitted immediately after the absorption of the laser by the chromophore, it takes time. Thermal relaxation time is nothing but the time taken by the target like the hair follicle to transmit 50% of the heat generated by laser to surrounding tissue. If it transmits 50 % of heat to the surrounding tissue means there will be a reduction of 50 % of heat at the target tissue, so Thermal relaxation time can be defined as the time taken to transmit 50% of the heat to surrounding tissue or can also be defined as time taken by target to cool down of temperature by 50%.

Thermal relaxation time of few of potential targets:

Epidermis – Around 1ms

Thin to thick hair – 30 to 100ms

Velus hair around 10ms

0.1 mm diameter vessel – 10 ms

0.4 mm diameter vessel – 80 ms

0.8 mm diameter vessel – 300 ms

* TRT above mentioned are approximate values (different materials have different value)

**Depth of penetration:** It is the depth to which a laser penetrates or reaches the tissue on the application of a laser beam. Different lasers will have different depths of penetration. Following are the depth of penetration few lasers.

Diode : 3 to 4 mm depth - Nd:yag : 4 to 7mm depth - KTP : 1.5 mm depth

**Laser Wavelength:** This is the length of the laser wave mentioned in nanometer (nm). All the lasers will have particular wavelength. This wavelength decided the characteristics like chromophore, penetration depth, chromophore absorption coefficient, etc.

Nd:yag laser wavelength is 1064nm

KTP laser wavelength is 532nm

Co2 laser laser wavelength is 10600nm

Erbium:Yag laser wavelength is 2940nm

Diode laser can be manufactured at many wavelengths like 800nm, 808nm, 810nm..... Even diode is manufactured to produce ndyag wavelength, alexandrite wavelength )

## Working principle of laser hair removal:

When a laser having a chromophore of melanin is applied to the skin, it destroys the hair follicle by the heat generated from the laser absorption of melanin in the hair follicle. When the laser passes on the skin surface, it travels through the epidermis and reaches the hair root in the dermis to selectively destroy the hair follicle (Selective photothermolysis). The epidermis also contains melanin that may not be equal to concentration in hair but it is higher in dark skin than lighter

skin. So the melanin in the epidermis also absorbs the laser and generates heat before it is absorbed by the hair follicle. Because of this absorption of the laser by epidermis melanin, while destroying the hair root, the epidermis also gets burnt. This is where Thermal relaxation time plays an important role in destroying hair follicle without damaging the epidermis. Let us see it in stage wise as below.

Target : Melanin in hair removal

Require : Laser with melanin as chromophore

Challenge : To prevent the epidermis from thermal damage by the heat generated due to laser absorption of melanin in the epidermis.

Solution: Thermal relaxation time.

Let's see how we use this thermal relaxation time concept to destroy hair roots without damaging the Epidermis.

When you apply a laser it is continuous, if it is applied for a very short time then it becomes pulsed. We use continuous lasers mostly in surgery to cut, coagulate, and vaporize the tissue. To work on this thermal relaxation concept we need a pulsed laser.

If you see the thermal relaxation time of the Epidermis is less than 10ms or around 1ms second and the thermal relaxation time of hair is 30 to 100ms. It means when you pass a laser for more than 10ms time to the skin, the epidermis will conduct 50 % of the heat generated to the surrounding tissue and the heat generated by laser absorption in the hair follicle stays in the hair follicle, it is not conducted to the surrounding tissue because its TRT is 30ms and more .

So by choosing the pulse of the laser, which is greater than the thermal relaxation time of the epidermis (1to10ms) and less than the thermal relaxation time of the hair follicle (30 to 100ms) we can selectively destroy the hair follicle. The epidermis is still not safe by doing treatment using above discussed pulse concept based on thermal relaxation time, because there is less temperature at epidermis than at hair follicles because of heat conduction to surrounding tissue (TRT) this may not be a safer temperature value for the epidermis. For example we are passing the laser to create a temperature 110'c ( example value) at the hair follicle to destroy it, similarly, there will also be a rise in temperature at the epidermis also but it will not be the same as110'c at the follicle because of the pulse we chose higher than its TRT , because of this temperature at epidermis could be 60'c or 80'c ( example value). So there will be a difference between the temperature at the epidermis and hair follicle because of TRT concept, it need not be a safe temperature value at the epidermis. To solve this we use additional external cooling to the epidermis to maintain the temperature of the epidermis in safe value. Hence almost all the machines come with cooling technology.

There are different types of cooling.

Parallel cooling: we cool the area parallely, which means before passing the laser, during lasing, and after passing the laser. This can be further subdivided into contact and non contact parallel cooling.

Pre and post cooling: Some machine comes with cooling before passing the laser and cooling after passing the laser. It doesn't cool during lasing.

Medium of cooling can be air, water, cryo and semiconductor

## Laser Hair Removal Procedure info:

- We have to shave the area before doing the treatment, if not shaved the hair shaft that is above the skin surface will absorb most of the laser, and then when the handpiece presses it against the skin while treating, it will burn the epidermis along with the hair shaft. The hair root doesn't get a sufficient laser to destroy it.
- If marking is needed do the marking before shaving with light colors like yellow or white marker.
- If the machine doesn't have precooling and you want to do ice pack cooling just glide the ice pack once, twice or thrice, don't apply for a longer duration this might affect the result also.
- Apply good quality gel, the gel should be colorless gel. It can be also cold gel.
- When you apply the laser, the handpiece should be in full contact and perpendicular to the skin. if there is an air gap, not complete contact between the skin and the tip of the handpiece, the diode laser will cause burns. There can be 10 % overlapping while doing the treatment.
- Post-laser treatment cooling can be done with an ice pack for a longer duration.
- Endpoint you can expect is erythema or perifollicular edema or hair pop-out
- Post-treatment sunscreen is a must.
- Treatment course varies from machine to machine, on average 4 to 8 session
- The treatment interval between sittings or sessions is a minimum of 25 days or when the hair grows back after 25 days.

- When doing laser treatment on edges like the ear, where the handpiece spot area is bigger than the treatment area (half of the laser tip is on the treatment area and the other is in the air) use wet cotton or wet gauze or wooden spatula on air gap to avoid burns.
- No threading or waxing between the sessions, only shaving is allowed.
- Velus hair is very difficult to get results
- If there is a hormonal imbalance, parallely they can be on treatment for hormonal imbalance.
- It doesn't work for grey hair.

## Logic of Treatment parameter:

In this topic, we are not going to discuss about specific values or detailed treatment parameter chart, because it varies with the type of laser (diode, ndyag) and are also slightly different from manufacture to manufacture depending upon the specification of the machine. We will be discussing the logic behind the treatment parameter.

### Parameters involve:

**Fluence :** it total laser energy delivered per unit area ( Unit: Joules/cm2)

**Pulse duration:** it is the total time the laser delivered on the skin (this is related to thermal relaxation time, we discussed) unit is millisecond ( ms )

Frequency ( unit herts:hz) : it is the number of the pulse delivered in a second ( it is adjusted based on how fast you want to move the handpiece during the treatment. If you want to move the handpiece fast by gliding on the skin you can keep higher frequency like 2 pulses per second ( 2 laser shots delivered in one second you

should move the handpiece to two areas in one second ) depending upon how fast you want to do the handpiece movement you can go up to 3 pulses per second). This parameter is nothing to do with the result, it is to do faster/Quicker treatment. 9n inmotion mode ( we will see later ) it is useful. This parameter we will keep it fixed to 1 hz,

**Let's take diode laser to discuss**

Fluence range we choose 15 to 50 j/cm2
Pulse duration we choose 30 to 100 ms
Frequency we keep at 1hz

❖ Let's fix the fluence at 20 joules and vary the pulse duration

20 joules and 100ms pulse produces **x** temperature at follicle

20 Joules and 50ms pulse produce **x +y** temperature at follicle

20 Joules and 30ms pulse produces **x+y+c** temperature at follicle

When you reduce the pulse duration the laser becomes more powerful

❖ Lets fix the pulse duration at 100ms and vary the fluence

20 joules and 100ms pulse produce x temperature at follicle

30 joules and 100ms pulse produce x+y temperature at follicle

40 joules and 100ms pulse produce x+y+c temperature at follicle

When you increase the fluence the laser becomes more powerful

❖ Let's vary the pulse and fluence both in proportion

20 joules 30ms pulse x temperature at the follicle

25 joules 50ms pulse almost x temperature at the follicle

30 joules 80ms pulse almost x temperature at the follicle

All three do not exactly produce the exact amount of heat but this is for example I have taken, all three temperatures will be very near to each other. When you want to increase both parameters and produce effective treatment you have to increase higher value on fluence with small increase in pulse duration.

( Joules mentioned though out this material is joules/cm2)

- The longer or higher the pulse width the safer the treatment, lesser the energy the safer the treatment.
- In a nutshell, by increasing the fluence value the laser delivery becomes more powerful, and by decreasing the pulse duration value the laser becomes more powerful

Parameters based on skin colour ( fitzpartick) and Hair thickness

❖ If it is dark skin with thick or thin hair (Fitzpatrick Skin type V and VI )

Always choose a longer pulse duration of 100ms or greater because melanin content is more in the epidermis, to treat safely

Choose fluence above 18Joules give one shot and ask for feedback from the patient do they have a rubber band snap sensation or do you see one of the endpoints?, discussed in the previous topic.

Actually for thin hair pulse width should be shorter or less than 100ms as per the thermal relaxation time topic studied earlier, but for safety reasons to avoid burns we choose 100ms or higher.

- If it is fair skin (Fitzpatrick skin type III & IV) Thick hair

Keep the pulse duration at 50ms or 80ms and increase the fluence till the patient feels a rubber band snap sensation or you see one of the three endpoints

- If it is fair skin (Fitzpatrick skin type III & IV) Thin hair

Keep the pulse duration at 30ms or 50ms and increase the fluence till the patient feels the rubber band snap sensation or you see one of the three endpoint

- If it is fair skin (Fitzpatrick skin type ,I & II) Thin hair & Thick hair

Keep the pulse duration at 20 or 30ms increase the fluence till the patient feels the rubber band snap sensation or you see one of the three endpoints

## End of Section 1

# SECTION 2

## Various Technologies/types of machines for Laser hair removal?

Following are the various laser technologies available for Laser hair removal treatment.

- Alexandrite Laser
- Diode Laser
- Long pulsed nd:yag
- IPL ( intense pulsed light)

## Alexandrite Laser:

This is a solid-state laser with a wavelength of 755nm. It is delivered through fiber optic cable to the handpiece and needs good skin cooling to do treatment safely. The pumping source is a flash lamp or an arch lamp. This flash lamp or arch lamp is a consumable, which needs to be changed after eg. 500 hours or millions or billions of shots. The fiber optic cable that is used to deliver to the handpiece is also consumable, which needs to be changed after a particular life. Like other hair removal lasers, its primary chromophore is also melanin. The absorption level (absorption coefficient) of alexandrite laser on melanin is high compared to other hair removal lasers. Because of this high absorption level, it treats hair removal more effectively than other hair removal lasers, this doesn't mean this is the best laser for hair removal, we will analyze this in the lasers comparison topic.

## Diode laser:

Diode laser is a semiconductor laser that also comes under the category of solid state laser. This is similar to the LED light we use for decoration in photo frame, Led sign board, it is also a diode with slight modification but produces light instead of a Laser. Here you don't need any additional pumping source like in other lasers (flash lamp or arch lamp) to produce laser, instead, it uses current as a pumping source. So there is no consumable in the diode laser. Since this diode laser has no consumable like an arch lamp or flash lamp as in alexandrite laser, it doesn't have exact life, you can say only expected life, usually, it is mentioned in millions or billions of shots. So it need not be changed at exactly the expected lifetime, sometimes it comes more than the expected lifetime or sometimes it breaks down before the expected lifetime. In almost all diode lasers, the laser is produced in the handpiece, machine ( main unit) has only electronic components, not laser cavity. It is called diode bars that are available in handpiece to produce laser, you will have a number of bars in handpiece based on the wattage of the machine. The following figure shows the sample diode laser bar. Here are two columns of diode bars, usually you will have only one column


figure.1 Diode laser bar

The figure. 1 shows 30 bars diode laser. Each metal line is one laser bar. This is integrated into the handpiece, and from this, only the laser is produced. Different machines have different numbers of laser bars, the number of laser bars and the value of each bar decides the wattage of the machine. The usual wavelength of diode laser is 800nm or 808n or 810nm. The diode laser can be manufactured to produce different wavelength, (it can be designed to produce 800nm or 808nm or 810 or 910nm or 1064nm) Like other hair removal lasers its primary chromophore is melanin. Here laser absorption level in melanin (absorption coefficient) is also high but less when compared with the Alexandrite laser. This also treats hair removal very effectively. It also requires good cooling to treat safely.

## Long pulsed nd:yag

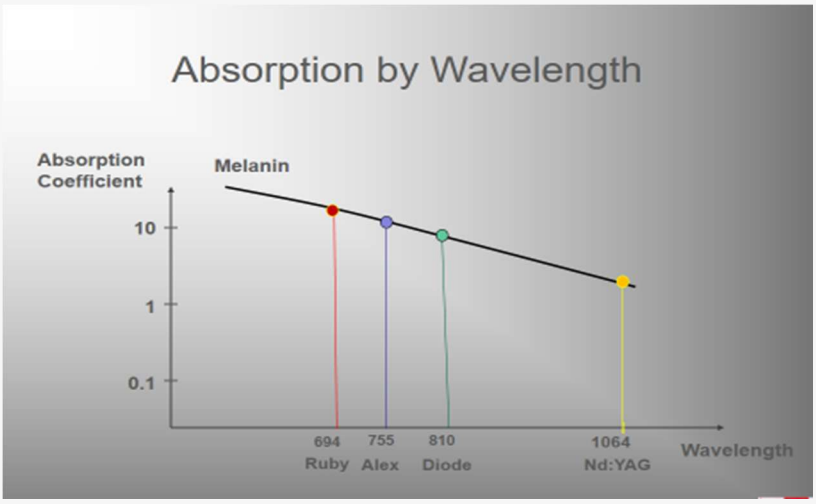
This is also solid-state laser with wavelength of 1064nm. This uses fiber optic cable to deliver the laser to the handpiece. Here the laser is produced in the machine (main unit) and it is transported to the handpiece through fiber optic cable. Few machines have laser produced in handpiece ( ndyag rod will be in handpiece), mostly they are platform systems, multiple lasers in a single machine. It also has an arc lamp or flash lamp as a pumping source, so the flash lamp and fiber optic cable is a consumables like in an alexandrite laser and need to be changed after a specific life, to get good stable output power. Like other hair removal lasers, its primary chromophore is also melanin. Here the level of laser absorption in melanin (absorption coefficient) is less compared to alexandrite and diode laser, hence ndyag manufacturers claim it is safe to use on dark skin. This also treats hair removal very effectively.

## IPL (Intense pulsed light)

This is not a laser, it is a high-power flashlight but mentioned under the laser hair removal category. This is a multiple application machine, not like a laser only for hair removal, ndyag can be used also for leg vein treatment. It doesn't have one particular wavelength, but has a range of wavelength. Usually, the Ipl machine produces 300 to 1200nm wavelength a. We can select the range of wavelength by using a filter from 300 to 1200nm according to the treatment application. Like diode laser, here also laser (light) is produced in the handpiece, it has a lamp in handpiece which produces the range of wavelength. We use a glass filter (coated) at the handpiece to select a particular range. For eg. if we insert a filter in the handpiece it will give 415nm to 1200nm wavelength, another filter will give 550nm to 1200nm, and another 700nm to 1200n. According to the wavelength range the application changes, apart from hair removal, it can be used for acne treatment, skin rejuvenation, vascular lesion treatment and pigmented lesions. Different manufacturers will have different wavelength ranges (filter). Usually, for hair removal it will be from 600nm to 1200nm or 620nm to 1200m to 1200nm or 650 to 1200nm or 700nm to 1200, it usually varies from manufacturer to manufacturer but all of the range gives almost the same results. (We will see in detail on IPL in other info notes volume dedicated only for IPL). The lamp which is used in the IPL to produce laser (Light) is consumable it will have a life of 30,000 shots or 50,000 or ..... It needs to be changed exactly after that number of shots to get good power output. Here the melanin absorption coefficient is based on the quality of the filter used and the wavelength range selected. It also varies from machine to machine. This also gives effective treatment for hair removal.

## Comparison of Various Technologies

Now we have four technologies to compare. We will be comparing all of them based on the results and safety, comparison by considering other factors can be seen in the guidelines for the selection of laser topic.




The above graph shows the comparison of the absorption coefficient of different lasers

Ruby laser is not in use now, so we ignore it. ( the below comparison is without considering the machine specification because two different brands of the same laser technology will not have the same specification and same performance ) Among the three laser technologies, Alexandratie has the highest melanin absorption, so it is well absorbed by melanin when comparing diode and ndyag. This doesn't mean the melanin absorption coefficient isn't sufficient for hair removal treatment in diode and ndyag laser.

Let's understand by comparing it with another example.

You have three surgical knives of different sharpness, let's name A, B, and C knife.

A has sharpness of x

B has sharpness of x+1

C has sharpness of x+2

We need to cut a tissue to a the depth of 5 mm

if surgeon applies the force/pressure of y+2 in A knife it will cut 5mm depth

if surgeon applies the force/ pressure of y+1 in B knife it will cut 5mm depth

if surgeon applies the force/pressure of y in C knife it will cut 5 mm depth

So all the three knives can cut the same depth in the same tissue only the pressure/force applied to the knife varies, The same is the case with alexandrite, diode, and ndyag laser because of differences in melanin absorption coefficient, their will be different in energy ( fluence ) and pulse applied to the same treatment. You can have a comparison of the treatment chart of the Alexandrite laser, Diode laser and ndyag laser. Alexandrite energy ( fluence ) setting will be lesser than the diode and diode ( fluence) setting will be lesser than ndyag laser.

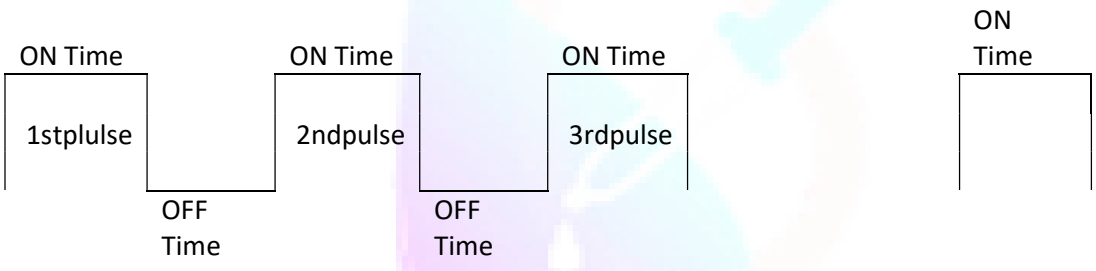
Does this mean all three lasers are equal in performance? no, it's not equal in performance because of the following reasons.

The performance will be almost the same only in lighter skin, when it comes to darker skin diode is a little safer than alexandrite and ndyag is a little safer than a diode, still it all depends on the user's mastery over the machine irrespective of technology. In skin type V and VI even the ndyag laser will produce burn while keeping an aggressive setting to get results. Both diode and ndyag are suitable for treating all the skin types to get good results. This is not the end of the

comparison there is one more point that also needs to be considered which is the safety margin, we will see it under the guidelines for the selection of laser topic

Ipl is totally different technology compared to laser but the results are

comparable. Here we use a range of wavelengths, than a single wavelength for treating hair removal. So melanin absorption coefficient will be a combination of multiple wavelengths, which varies from machine to machine based on filter range and quality of filter and machine. Like lasers, the energy is not delivered in a single pulse, it is delivered in multiple pulse or train of pulse. So you have on-time and off-time and number of pulses setting in IPL.




Ipl multiple pulse structure Laser single pulse

So in ipl we have multiple parameter to set they are given below.

1. fluence ( energy),
2. Number of pulse
3. Ontime of 1st pulse
4. off time 1st pulse
5. ontime of 2nd pulse
6. off time of 2nd pulse
7. ontime of 3rd pulse

If we change all these settings you get so many combinations of treatment settings. The treatment chart becomes more complex / wider or lengthy, to make it

simpler, we keep on time and off time on a particular value or vary less and vary only fluence value according to skin type and hair thickness. Ideally, you need to vary all the pulse on time and off time settings according to skin type and hair thickness along with fluence.

If you compare the result of ipl with other laser, it can also give results equal to other laser but not better than other laser. Comparing to lasers, in ipl the operator needs to have more mastery over the parameter setting, and need to master in varying on-time and off-time of all the pulses along with fluence setting to get the best results like a laser. Here learning curve is long compared to other lasers. On average ipl results will be a little less than laser or a longer number of sessions if ideal settings are not chosen.

## Right laser parameter selection & good treatment guidelines:

- Follow the treatment chart (treatment protocol) provided by the manufacture initially. Users need to develop his/ her own treatment chart (protocol) over the period because most of the manufacturer's treatment chart (protocol) will have more focus on safety and it will give you a range value or approximate value. Most of the users over the period will have their own treatment protocol, which would be better than the treatment protocol provided by the manufacturer.
- First, choose the pulse duration based on skin color and then select the fluence (both are interrelated).
- After selecting the pulse duration, choose a starting fluence and fire one shot and see the skin response, if there is perifollicular edema Or hair pop out then maintain the same setting, else increase the energy till you get the endpoint in a lighter skin type. If you are not getting perifollicular edema in dark skin don't increase the energy, because chances of burns. Check with

the patient if he or she felt rubber band snap sensation, if he didn't feel than increase both pulse and energy proportionately to do safe treatment on dark skin. if you are sure you can increase only energy without changing the pulse duration.

- Always use higher or longer pulse duration for dark skin irrespective of hair thickness to avoid burns. Pulse duration 100ms and above are safe for all skin types.
- Use 30ms and below only on lighter skin type
- Note down the treatment settings as per the treatment form given in the next topic.
- Every session you need to increase the energy based on the result or endpoint you got in the previous session. If the endpoint is perifollicular edema or hair pop-out in the previous session you don't have to increase the setting in the current session. If it is erythema or rubber band snap sensation in the previous session you need to increase the energy in this session.
- When you are getting hair pop out, you need to wipe the tip after every shot or few shots because the hair root that popped out will stick to the handpiece tip and when you place it on a new area this hair which comes in contact with skin will absorb the most of the laser and burn the skin ( epidermis).
- Always apply the required energy to destroy the hair root, because giving less energy to the hair root will damage partially and the thick hair that is treated will become fine hair or very thin hair in the next session, then it becomes difficult to treat. So always give ideal energy to destroy the hair permanently, instead of moving the hair from thick to fine hair or very thin hair, which is difficult to treat. Even less energy can cause paradoxical hair growth but its chances are very less.

- When you apply the laser, the handpiece should be in full contact with the skin, if there is an air gap diode laser will cause burns. There can be 10 % overlapping while doing the treatment.
- If you are using icepack for precooling don't ice it for longer duration, this will affect the result, just glide it once, twice or thrice.
- Post laser application cooling can be done with ice pack for longer duration.
- Treatment interval between sessions is minimum of 25 days or when the hair grows back after 25 days. If there is no hair growth even after 30 days don't do the next session, wait for the hair to grow back otherwise the treatment will be ineffective for that session. Sometimes there will be a long delay in hair growth.
- When doing laser treatment on edges like the ear where the handpiece spot area is bigger than the treatment area (half of the laser tip is on treatment area and other is in air gap) use wet cotton or wet gauze or a wooden spatula on the air gap to avoid burns.
- No threading or waxing between the sessions only shaving is allowed.
- If the therapist is doing the treatment, during the consultation of every session, the doctor can analyze the results and guide the therapist by writing the recommended treatment setting on the treatment form table and can provided to the therapist or laser technician for treatment ( instead of therapist choosing setting on her own).

## Treatment form:

Following is the sample treatment form for recording the treatment parameters. You can more columns to it based on the machine model used for the treatment.

# Laser Hair Removal Treatment Form

| Patient information | |
|---|---|
| Name : | Age : |
| Patient ID : | |
| Fitzpatrick Skin Colour : | |
| Treatment Area : | |
| Address : | |

| Session | 1 |
|---|---|
| Date | |
| Hair thickness | |
| Fluence | |
| pulse duration | |
| Mode | |
| End point | |

| Session | 2 |
|---|---|
| Result of previous session in % | |
| Date: | |
| Hair thickness | |
| Fluence | |
| Pulse duration | |
| Mode: | |
| Endpoint | |

The above figure shows the sample tabular column of the Laser hair removal treatment form. The first few columns are to enter the patient details. We need to enter the patient skin color based on Fitzpatrick skin colour classification, skin color plays a very important role in choosing the treatment parameter (discussed Earlier). If a patient with multiple treatment areas like face and underarm, a separated form for face and underarm should be used even for the same patient.

## Session 1

Fluence and pulse duration are filled as per values chosen from the treatment chart provided by manufacturer or user-made treatment chart. Hair thickness is the thickness of hair before treatment (Thick or Thin or velus hair )

Mode is nothing but standard stamping mode (shot by shot) or inmotion mode ( almost continuous mode) . When you chose the inmotion mode you need to enter the total energy delivered apart from the fluence value selected.

The endpoint is the skin response after the treatment, it will be erythema or perifollicular edema or hair pop out or only rubber band snap sensation with no skin reaction. This is needed for the next session to decide the setting of the laser.

## Session 2

In session 2 we have an additional column of the Result of previous treatment. This is mentioned in percentage, how much percentage of hair reduction you got (5 % or 20 % or no improvement)

In this session, Fluence and pulse duration is decided based on the result of hair percentage reduction you reached after the previous treatment and also based on the endpoint you got in the previous treatment. If you got 10% or more hair

reduction after 1st session you can maintain the same setting (fluence and pulse duration). If you got endpoints like perifolicullar edema or hair pop-out in1st session also you can maintain the same setting (fluence and pulse duration) else you need to increase the fluence. Hence noting the endpoint in every session is very important to decide the laser setting for the next session.

### Session 3 to . . . . :

The tabular column of Session 2 is repeated for other sessions

## Latest Advancement in laser technology / new technology

Following are the latest advancements in laser hair removal technology.

**Inmotion mode:** This is not the latest advancement but this mode was not available when hair removal lasers were launched before 20 years. This has been in the market for more than 7 years. Let's see about this.

We saw in Section 1 the stamping mode, in stamping mode we apply/pass laser shot by shot. Only one laser shot is delivered in one particular place, then handpiece is moved to the next location to deliver the next shot, this is stamping mode. In motion mode, we deliver multiple shots in a single location. The laser is kept at a high frequency, in one second the laser will deliver 5 or more number of shots. So you have to just glide the handpiece at a certain speed of movement. This is mainly developed to treat larger areas in less time. This in-motion hair removal is not based on the thermal relaxation time concept, which we saw in p section 1. This is based on the cumulative heating effect. Here we use energy (fluence) which is 1/3 of energy ( fluence ) in stamping mode or even less, it is delivered in a higher frequency of 5 hz or more. In motion mode, multiple shots are delivered in the same area, whereas in stamping mode only one shot is delivered

per area. Even though the energy is very less at the first shot there will be a minimum rise in temperature at the hair root on second shot there will be a further increase in temperature when you deliver 4 or 5 shots in the same place at the end of the 5 th shot the temperature in hair root will rise to threshold level to damage the root. Here we mark a larger area like 10cm2 ( back or chest ) and set minimum fluence and glide on the surface at a constant speed. Here we choose minimum energy ( fluence) that is per shot energy and when you glide you have to calculate the total amount of energy delivered in total shots. As you glide the handpiece the machine calculates the total energy delivered with every increment of shot. As per the treatment chart you have to deliver x amount of total energy at the end of treatment, you have to do multiple passes till you reach the desired total energy. This mode is mainly used for larger area.

When you compare this mode to stamping mode, the advantage of this in motion mode is larger area treatment in less time and it is safe, chances of burns are very less even in darker skin compared to stamping mode.

The disadvantages of this mode is the variable result, you cannot deliver precise energy to all the areas like in stamping. You don't have control over the result like in stamping mode. The user has to be very skilled in moving the handpiece in a constant speed. You cannot exactly deliver a same number of shots to all the area, you can only deliver the sum of total energy to the area. Some of the users feel this mode gives better results than stamping, as per theory stamping mode gives better results than inmotion mode.

**Bipolar RF with Diode:** This technology also was launched more than 7 years ago. Here we use bipolar RF along with diode laser. Rf current when passed on the tissue it generates heat when it flows. This heat generation is because of the resistance of the tissue. Here we are using this technology to heat the hair root.

This is bipolar Rf which has two parallel plates, Rf current flow between the plate.

The manufacturers of this technology claim that since Rf is color blind (not absorbed by melanin) without affecting the epidermis it heats the hair follicle to some temperature and diode laser also heats hair follicle to destroy it. Hence it can be safely treated on dark skin because diode energy required will be less because of RF heating the follicle. Actually as per theory Rf doesn't heat different thicknesses of hair in the same way, when it heats, it heats almost the whole skin tissue, not selectively hair. This Rf technology is very successful in skin tightening, one or two manufacturers only have this technology for hair removal. Practically even by the users, it is very difficult to identify whether the results are only by diode or also by a combination of both technologies. I couldn't get user made treatment chart or manufacturers' treatment chart to find out whether it ( Rf ) really contributes to the results on dark skin. In light skin we don't require Rf it will be a hindrance to the diode laser.

## Diode based ndyag wavelength (1064), diode based alexandrite wavelength (755):

Diode laser is used to produce ndyag laser wavelength or alexandrite laser wavelength. Here no ndyag rod or alexandrite is used. Diode with a modification called doping to produce these wavelengths. The characteristics what we saw in ndyag laser and alexandrite laser and this diode-based ndyag, alexandrite laser are the same. Here laser is generated in handpiece not in main unit and there are no consumable like arc lamp or flash lamp or fiber optic cable to delivery.

## Tripple Wavelenght laser

This technology was launched around 3 years ago. Which uses three different wavelength in combination to do laser hair removal treatment.

**Tripple wavelength (755nm, 810 and 1064nm) model laser**: Here diode laser which produces alexandrite wavelength (755nm), diode wavelength (810nm) and ndyag wavelength (1064nm) from a single handpiece. Actually we saw diode bars photo in the beginning of the discussion. Here also we will have many diode bars, in that a few bars will generate 755nm, a few bars will generate 810nm and a few bars will generate 1064, at the handpiece tip you get all three lasers, All three lasers are delivered in a single shot. The reason for the development of this technology is to combine the advantages of all three wavelengths. The advantages are 755nm (alexandrite) will have very high melanin absorption and penetrate superficial depth compared to the other two wavelengths. 810 (diode) wavelength has a medium melanin absorption coefficient compared to the other two wavelengths, 1064 (ndyag) has a very less melanin absorption coefficient compared to the other two lasers and goes deeper than the other two lasers.

Following is what the manufacturer of this technology claim

[ Alexandrite 755nm : The Alexandrite wavelength offers more powerful energy absorption by the melanin chromophore, making it ideal for the widest range of hair types and color- specially light colored and thin hair. With more superficial penetration, the 755nm wavelength targets the Bulge of the hair follicle and is especially effective for superficially embedded hair in areas such as the eyebrows and upper lip.

Diode 810nm The classic wavelength in laser hair removal, the 810nm wavelength, offers deep penetration of the hair follicle with high average power, a high repetition rate and a large 2cm spot size for fast treatment. The 810nm has a moderate melanin absorption level making it safe for darker skin types. Its deep penetration capabilities target the Bulge and Bulb of the hair follicle while

moderate tissue depth penetration makes it ideal for treating the arms, legs, cheeks and beard.

ndyag 1064nm : The ndyag 1064 wavelength is characterized by lower melanin absorption, making it a focused solution for darker skin types. At the same time, the 1064nm offers the deepest penetration of the hair follicle, allowing it to target the Bulb and Papilla, as well as treat deeply embedded hair in areas such as the scalp, arm pits and pubic areas. With higher water absorption generating a higher temperature, the incorporation of the 1064nm wavelength increases the thermal profile of the overall laser treatment for highly effective hair removal. ]

Lets analyse this model at the end of this topic

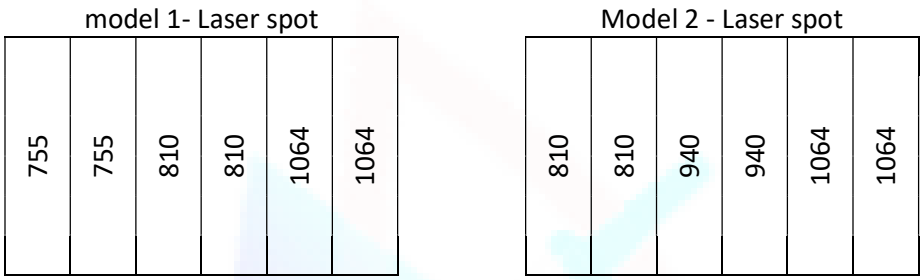
**Tripple wavelength (810nm, 940 and 1064nm) model 2 laser:** This is also similar to the above discussed model instead of 755 diode laser in the previous model, it has 940 diode wavelength. Here the manufacturer claims 940 has a medium depth of penetration, which lies in between 810nm and 1064 nm depth of penetration. So we have 810 superficial depths which target the shaft, 940nm medium depth which targets the bulge and 1064nm deeper penetration depth, which targets the bulb.

Lets analyse both models, actually, both the models were mentioning about using there lasers for three different levels of depth for effective treatment to destroy the hair. Practically this is not a big advantage any one depth will do effective treatment, we don't require their different depth.

Combining the three different melanin coefficients of three different lasers is an advantage but the delivery doesn't seem to give a mixture of all three wavelengths in both the models. I checked with one of the service engineers, whether at the laser tip we get a mixture of all three laser wavelengths or Each separate line of laser in a single spot. He replied that all three are not mixed and delivery at the

laser spot you get one line ( one or two bar) of 755walelenth, one line (one or two bar) of 810nm and one line (one or two bar ) of 1064nm. In model 2 - one line ( one or two bar ) of 810walelenth, one line (one or two bar) of 940nm and one line (one or two bar) of 1064nm. In same place all the three wavelength are not passed.

It will be like in the following figure



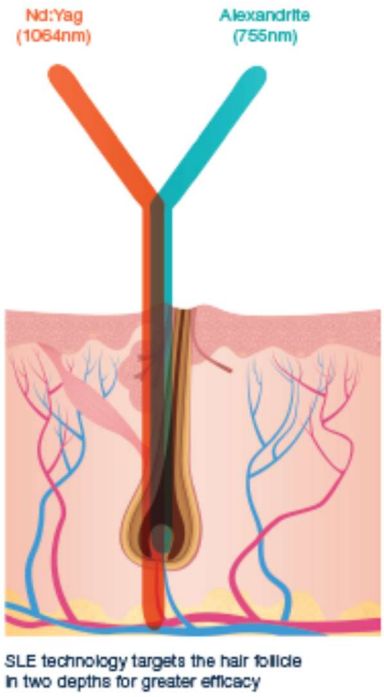

Above figure is just for illustration, not of exact dimension or number of laser bar

If the laser is not mixed at the output then it doesn't have combination effect of all there laser. One treatment area will be exposed only to 755 and another only to 810 and another area will only 1064, all three wavelength are not exposed to same area. But in inmotion mode, since you are moving at constant speed and delivering more than one shot at particular place, there are chances you can deliver all three lasers in same area, only chances are there not guaranteed or precise delivery of all the three laser to all the treatment area.

**Alexandrite and ndyag (1064 & 755) nm:** This model was launched around 1 year ago. Following is what the manufacturer claim

[Synchronized Laser Emission: Alexandrite & ndyag Powerful, fast and versatile machine treats the widest range of hair removal procedures .Its Alexandrite 755nm and ndyag 1064nm wavelengths can be synchronized to fired independently or simultaneously, with varying proportions to tailor treatment, according to the

individual's skin type, hair color and thickness allowing safe and effective treatment.]




The adjacent image shows how the both wavelength are delivered to same area. As per my understanding here it is not mixed, but delivered in sequence first ndyag and then alexandrite to the same treatment. In this technology all the treatment area will be exposed to both lasers (ndyag and alexandrite) very precisely. I feel this technology is better than the previous triple wavelength laser. This theory seem to have combined efficacy of both the wavelength with respect to result and safety.

There are few more latest advancement in Laser hair removal technology, but what we saw till now are important ones.

## Guidelines for the selection of laser machine

First, let us choose the technology ( alexandrite or Diode or Ndyag or Ipl) that will suit your requirements. Let's analyze the guidelines for choosing the technology

We already discussed about each technology and the comparison among them in terms of results and safety.

## Choose diode if following is following is our requirement.

1. If you get a mixture of both dark and light skin patients, who will give equal preference to both result and safety.
2. If you have more patients who expect faster results ( less number of sessions)
3. If you & therapist both do the treatment.
4. Choose diode if you are planning for cost cost-effective make like Chinese or Korean. Because this technology even at lower manufacturing costs you can get good quality, this doesn't mean all the Chinese and Korean make are good quality lasers, many can be good quality machines at lower price.
5. If you are planning to keep treatment charges very minimum, where you cannot afford recurring consumable costs like flash/arch lamps or fiber optic cable and breakdown repairing charges. Diode technology is usually sturdy and less breakdown technology compared to Alexandrite and ndyag.
6. If you need a portable model planning to shift the machine between the clinics, this technology comes in a portable model and is sturdy enough to be transported. American portable models are even more sturdy, I used to use one American make portable machine 15 years back on demo rental, it is transported all across India, some place you don't get good vehicles to transport the machine, so there will be a lot of vibration still it was working fine without any problem. The transporting case had only a thin layer of thermacol cushion. Once it slipped from my hand around 1to 2 feet height while lifting, nothing happened. I am not sure even the same manufacturers are producing models that are sturdy like the old model (this old model is discontinued now). I would have done more than 300 treatments (most of the treatments are on dark skin patients), got only a single burn out of 300 cases ( that patient skin was very sensitive even at starting fluence she got burns in

both two sessions, we dint continue treatment for that patient ) and also i got burnt while testing the machine on my hand. Almost all the patients (iam not mentioning all patients because I don't remember completely) were happy with the progress of the result. In many cases easily we used to get perifolecullar edema and many cases of hair pop out. If there is a burn after the treatment, after healing if there is hyperpigmentation, you can do qswitch ndyag treatment for the hyperpigmentation. This hyperpigmentation goes easily by qswitch in 1 or 2 session, even with low power portable Chineses q switch. When I get burn with diode or ipl machine while testing, I treat it with Chinese qswitch.

7. If you are planning for platform model with multiple laser for multiple application choose diode. Only diode and ipl can be integraded in a platform system / model ( multiple laser in a single machine) without compromising the good specification. When you integrate alexandrite or ndyag in platform, the specification is compromised, the platform model ndyag laser will not be equal to standalone unit ndyag specification or it won't be very sturdy

## Choose ndyag if following is your requirement

1. You get an equal mixture of light and dark skin patients or more dark skin patients, who will give equal preference to result and safety or more preference to safety (avoiding burns).
2. If the patient accepts a slightly longer treatment course ( 1 or 2 session more than average treatment session) Practically you will find in ndyag the session will be extra which is not as per theory. If diode takes 4 to 6 sessions for laser hair removal, ndyag may take 5 to 8 sessions. The number of sessions is based on the proper setting you keep during the treatment. Normally it takes 4 to 8 sessions irrespective of the type laser technology ( alex or diode or ndyag or ipl) used. Sometimes sessions can be less than 4 session and longer than 8 sessions.

Usually, you get less number of session in lighter skin with thin or thick hair on good treatment setting and you get more number of session in dark skin.

3. If the therapist does the treatment most of the time. (Because the safety margin is more in ndyag than other lasers, this safety margin we will discuss later).
4. Plan for ndyag only if you have a good budget for American make, because in ndyag technology a cost-effective Korean make will not be sturdy, and might have more breakdown but result wise Korean make could be comparable with American make. No for Chinese make ndyag, mostly not good quality ndyag are manufactured by Chinese company. I am discussing only long pulse ndyag not qswitch ndyag for tattoo. Normaly ndyag technology machines price are higher than diode lasers.
5. You need to charge little higher treatment charges because of the consumable cost of arc lamp/flash lamp, fiber optic cable, and a little more number of breakdowns than diode laser. Some ndyag technology use cryo for cooling the skin, this is the additional consumable charge.
6. These machine size are not portable and it is not sturdy enough to be transported frequently.
7. If your requirement is a standalone unit not a platform for multiple application.

## Choose IPL if following is your requirement

1. This suits for all type of skin colour because multiple range of wavelength. It doesn't mean it is very safe in darker skin, it is safe like lasers in darker skin not better than (this statement is discussed without considering machine speciation) laser. Certain specification of Ipl will deliver higher energy safely

than laser. This we will see is evaluation / choosing laser based on specification topic.

2. If you need multiple applications (hair removal, skin rejuvenation, acne, pigmented and vascular lesion) in a single machine.
3. Require cost-effective machine or planning to allot less budget for the machine. You get good quality ipl machines in many Chinese make (not all Chinese make are good quality), American make or Korean make is very expensive.
4. Here number of sessions will be higher on average. ( many factors are involved to give an exact number of sessions)
5. Here the treatment setting selection can be simple (keeping pulses setting almost constant and varying the energy) or very complex ( if you vary both the energy and pulse parameters like number of pulses, on time, off time ).
6. Here learning curve is very long if you want to get results equivalent to the laser. You need to invest more time to learn practically ( theory will just guide you)
7. Here you have a consumable charge of lamp to be replace after 40,000 or 50,000 . . . shots. This should be included in the patient treatment charge.
8. This comes in both portable and tower model. This portable model is not as sturdy as portable diode laser models, still, you can transport it safely between the clinics.
9. This technology can be integrated in to platform system without compromising on good ipl specification.

**Now we have chosen the technology based on our requirements, now let us analyze specifications required for the machine.**

**If you have chosen diode laser and let us see specification of the machine**

1. Fluence (J/cm2): The required range should be 10 (min) to 60 (max) or even higher. ( having a higher fluence of more than 80joulse is of no use )

2. Pulse duration (milli second, ms): minimum values should be 10ms or lesser and maximum value can be100ms or higher. Having pulse duration of more that 300ms is of no use.
3. Ideal spot size is between 10mm x 10mm to 10 x 20mm.
4. Contact cooling of -2'c to +2 'c , cooling should be parallel
5. In inmotion mode machine should have counter to calculate total energy delivered.
6. Power minimum of 600 watts or above. The higher the wattage machine is more power, let's see below how wattage plays an important role in the selection of the machine.

Above are the minimum required specifications, let's see important specifications in detail.

Pulse duration, fluence and wattage are the most important specification of machine that decides the performance of the machine. All three are interrelated.

Fluence and pulse duration are the settings that you vary during the treatment as per the treatment chart. The wattage is the capacity of the machine, it not displayed or you cannot change them in the display.

While selecting the machine don't go as per the catalog specification like minimum value and maximum value of pulse duration mentioned in the catalog. Minimum and maximum fluence mentioned in catalog and wattage rating mentioned.

You need to get the following data from the manufacturer.

1. Pulse duration range mentioned is 10 to 100 or 300 ms. Check is it in incremental of 10 or 5(eg 10ms, 20ms, 30ms, 40ms..... 100ms or 300ms) . Most of the manufacture will have pulse like 10,ms 30ms, 100ms 150ms 200ms and 300ms). Many machine will have preset setting of pulse and fluence, in the name like mode a, mode b or some name assigned or you need to choose skin type and hair thickness, the machine will automatically set the pulse duration. These feature are provided for the easy use of the machine to set the setting to perform safe treatment but this leads to limitations in the flexibility of choosing settings for better results. A good machine should have both preset setting mode as well as Normal mode to vary the pulse mentioned above.
2. If the fluence range mentioned in catalog like 10 joulse to 60 joulse or 100joulse, check whether this range can be changed independent of the pulse duration. For example, if you choose 30 ms pulse you should be able to vary fluence from 10 to 60 joules and similarly, if you choose 50ms you should be able vary pulse from 10 to 60 joules. Many machines will not have this provision normally for each pulse you cannot choose the full range of the fluence mentioned in catalog. In some models if you vary the fluence, the pulse also change with the change in fluence this is a drawback of the machine. Pulse and fluence should be independently varied. To understand this refer to the logic of the treatment parameter topic in the essence of Laser hair removal part 1.
3. Power (Wattage) this specification has been available since the hair removal laser was launched before 15 years, but not importance was given earlier during marketing the machine or evaluating the machine. Last 4 years manufacturers started mentioning to show the superior specification of the machine. But it is not clearly explained how it contributes to the results, there is also hidden logic of this power (watts) while evaluating the machine (this will be expanined in

detail in Laser physics info notes volume). For example two different machines of the same wattage will not have the same performance. Or some time lesser wattage machine's performance will be better than higher wattage machine.

Power (wattage) = energy / time

So a machine to have high power (wattage) it should be able to have higher value of energy (fluence) in less or short time ( pulse duration),That's why higher wattage machines like 1000watts or 2000wats or 4000 watts will have pulse duration starting from as low as 3ms. We need short pulse duration only during the treatment of fine or velus hair otherwise we don't require shorter pulse duration. Even with this short pulse duration, there is no guarantee to treat fine or velus hair only chances are there, it is difficult to treat. So this higher wattage specification is not a must. The required wattage is between 600 to 1000 wattage.

This topic should be preceded by a Laser physics topic to have an easy and clear understanding. Laser physics is covered in other info notes volume.

**If you have choosen ndyag laser now let us see specification required**

1. Fluence (J/cm2) required range should be 10 (min) to 100 (max) or even higher. ( having higher fluence of more than 100joulse is of no use )
2. Pulse duration (milli second, ms): minimum values should be 10ms or lesser and maximum value can be100ms or higher. Having pulse duration of more that 300ms is of no use.
3. There spot size is circular not square or rectangle like diode and it is between 10mm diameter to 20mm diameter

+ Other guidelines are same as in diode laser section above +

**We have choosen IPL laser now let us see specification required**

1. Fluence (J/cm2): The required range should be 10 (min) to 80 (max) or even higher. ( having a higher fluence of more than 80joulse is of no use )
2. We need to check the number of pulses, it should be a minimum of 3 pulses or higher.
3. On time and off time of all the pulses should be able to vary independently.
4. Ideal spot size is between 15mm x 5mm to bigger size.
5. Contact cooling of -2'c to +2 'c , cooling should be parallel cooling
6. Here we don't need power rating like wattage in laser to choose
7. Here in motion mode is available in some models but results are not like in laser in motion mode. This mode is not needed.
8. You need to check the make of the lamp, Even the Chinese make comes with German lamp and life should be 40,000 shots or more than that.

## Safety margin (my own theory not from any material):

This is the minimum increment value of fluence that can produce a change in unit temperature after laser is absorbed in hair root. Lest see in the following example.

(below is not exact value, example value taken for understanding)

### Diode laser:

20 Joule of energy laser produce x temperature in hair root

21 joule of energy also produce almost same x temperature in hair root

22 Joule of energy produce x + 1 temperature in hair root

So every 2 joule increase in energy we get change in temperature at hair root so the safety margin is 2 incremental. If 25 joules is the safe energy for this patient, by mistake if you keep 26 joules also it will not cause burn. Because

change in temperature is with incremental of 2 joules. The burn will be only at 27 joules.

### ndyag laser:

20 Joule of energy laser produce x temperature in hair root
21 joule of energy also produces almost the same x temperature in hair root
22 joule of energy also produces almost the same x temperature in hair root
23 Joule of energy produce x + 1 temperature in hair root

So every 3 joule increase in energy we get a change in temperature at the hair root so the safety margin is 3 incremental. If 25 joules is the safe energy for this patient, by mistake if you keep 26 or 27 joules also it will not cause burn. Because change in temperature is with incremental of 3 joules. The burn will be only at 28 joules.

### IPL:

For ipl many parameters are involved depending upon that the safety margin can be made lesser or higher than laser. This we will see in detail next info notes volume for only for IPL topic.

The safety margin for the Alexandrite laser will be lesser than diode

## Analyzing machines selection based on make

**American or German or Israeli Make:** Most of these makes are good quality, and they are developed based on proper Research and development. The only thing is machines are very expensive, machine parts are also expensive. Don't choose the

machines based on the before and after treatment data, they are real data but it is not average results documented data, all those data are only top results among average results data also they are done after research and high training.

When a new technology is launched like for example inmotion mode was launched in 2015, try to avoid going for machine in the same year of launch, wait for 1year. It's not about the results of the machine, it is about the hardware (electronic) quality of the machine. When new design is made for new technology, the hardware may not be perfect, practically when the user starts using they may come across problems in the machine, like power not being stable or some breakdown. They again change the design / modify other machines. If you are buying after 1 year there is less chance of hardware-related issues. This doesn't mean all the machines manufactured by all the company initially will have problems, no iam mentioning that there are only chances. These chances are less in American make (also based on the brand it varies), and its chances are more in Korean make when compared to American make, and much much more in Chinese make ( usually Chinese make are copycat models). The American makes are FDA approved, nowadays even some of Korean and Chinese machines are FDA approved. Does FDA approval mean that they are the best machines, no FDA has more to do with the safety of the machine than performance ( result). There is a certain class (based on the technology and application) in the FDA where without detailed testing of the machine by the FDA body you can directly start marketing just by applying.

**Korean or Italian make:** Most of these makes are medium priced and medium (good) quality and also reliable compared to Chinese makes. They don't do exactly the same Research and development on the latest technology like American or german make and develop the machine but they do to some extent, hence you don't

get detailed application guidance like American make. These machine's results also come near to American make, sometimes equal to American make depending upon the brand, technology, and model.

**Chinese Make:** These machines are well known in the market for their price and unfavorably known for quality. These machines are copycats of American make or Korean make. Even in Chinese make you can get good quality, it all depends upon the technology and manufacturer. You can get good quality diode lasers by some of Chinese manufacturers not all manufacturers produce good quality. There is a lot of development in Chinese making now they have an option for the user to choose even American or German parts in the machine, and the price will vary. They can also slightly modify the machine specification based on your requirement (either you have to give more price for that or you need to give more number of machine orders). Usually diode machine price of Chinese make will be approximately 50% less than the Korean make and when compared with American make the price will be 1/3 or ¼ of American machine. Actually if you choose diode technology you can go for Chinese make by custom design model option. You can go with your good requirement specification to a good Chinese manufacturer, they will modify or specially design a model as per your requirement specification, and with German and American imported parts (most of your specification can be done). But you have to give a minimum of 10 or 20 or 30 machines order. Actually you should give commitment or advance for 20 or 30 models but initially only one model should be made, because it should be tested for 3 to 6 months after that you can get the remaining machines. During testing of the machine for 3 to 6 months, if there are any faults, most of the manufacturers will rectify them by redesigning. These Chinese manufacturers sell directly to the user (doctors) they don't require a distributor for a particular country. So even a

group of 20 or 30 doctors can get the machine made as per their requirement and import it directly. If you choose ndyag technology never go for Chinese make, most of the manufacturers don't produce good quality long pulse ndyag. Ipl you can very well go for Good Chinese make.

Please share your feedback and suggestions to improve by emailing to skinscienceemail@gmail.com

Thank you

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* Swamy Guru Raghavendra *