A BRIEF GUIDE TO

Lasers and IPLs

AND THE TREATMENT OF

HAIR, TATTOOS AND BLOOD VESSELS

MIKE MURPHY
LISA MCMAHON

ED. 1.1

DERMA-LASE
LASER & IPL TRAINING

DERMA-LASE

LASER & IPL TRAINING

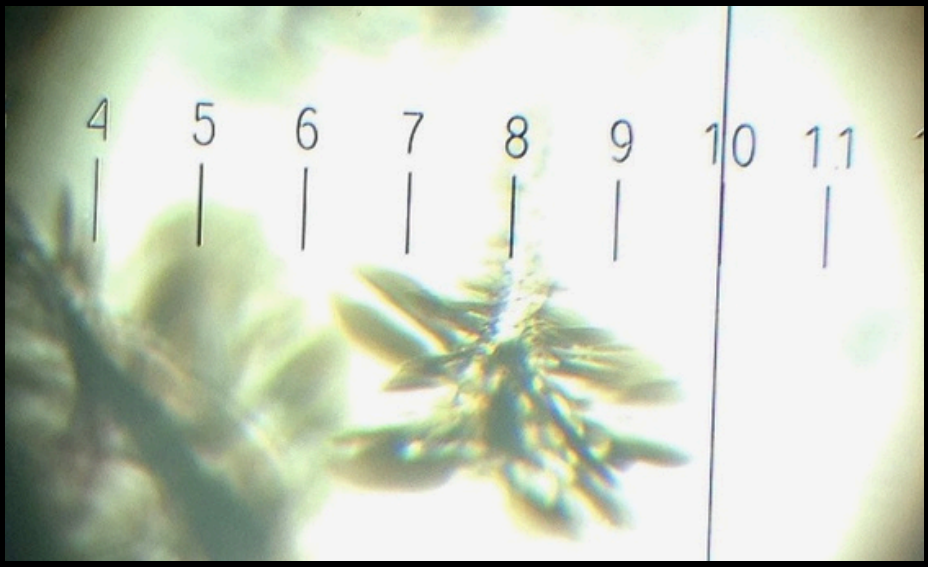


Table of Contents

What's it all about?

IT IS IMPORTANT TO UNDERSTAND THE VARIOUS TERMS AND EXPRESSIONS WHEN USING LASERS OR IPLS IN SKIN TREATMENTS. HERE WE WILL EXPLAIN WHAT THE MORE IMPORTANT TERMS MEAN...

Light Amplification by the Stimulated Emission of Radiation

Lasers were first built in 1960 by an engineer called Theodore Maiman. His first laser - a ruby - demonstrated a new way to generate light energy. Ths story goes that, when he demonstrated it to his colleagues for the first time, a chap at the back asked - "what does it do?"

They didn't know...

Intense Pulsed Light

The first IPL system was built by a Swedish engineer in the very early 1990s. He didn't want to spend ridiculous sums of money on American medical lasers and so chose to design and build his own version. The first system - the Plasmalite - could only treat blood vessels, but he, and PA Torstensson, went on to design a system for the purposes of hair removal.

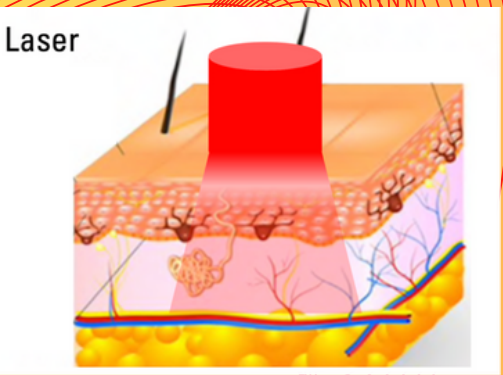
Terms and expressions

There are many terms and expressions used when describing laser/IPL treatments. It is important to fully understand these expressions, otherwise you may not obtain the best results possible.

Term	What it means...
Wavelength	The wavelength of light is essentially its 'colour'. Visible light exists in the range 400 to around 700 nanometres (nm) - this is from blue to red. Beyond the red part of the spectrum is the near-infrared spectrum, which is invisible to our eyes. But infrared light energy is typically felt as heat.
Energy	The energy of a beam of light is used to increase the temperature of the target - hair, blood, tattoos. The more energy we fire at these targets, the hotter they will become. We measure energy in 'Joules'.
Pulsewidth	Aka 'pulse duration' and 'pulse length'. The pulsewidth is how long a beam of light energy is applied - how long it is 'ON'. This may be from nanoseconds to milliseconds to hours! In some cases, a shorter pulsewidth will generate a higher temperature than a longer pulsewidth, simple because there is less time for the heat energy to 'escape' from the target during the delivery of the pulse. But sometimes, longer pulsewidths are better because they induce more 'cooking' of the target tissues.
Power	Power is simply how quickly, or slowly, we deliver the energy. If some energy is delivered over a short time, then its power is 'high'. If the same amount of energy is delivered over a long time, then it has a 'low' power. We measure power in 'Watts', named after the great Scottish engineer, James Watt.

Term	What it means...
Spot size	When we fire laser energy at skin, or paper or whatever, we can usually see an impression, of some sort. The size of that mark can be considered its 'spot size'. Many lasers fire circular spots and so we can measure their diameter and calculate their area. Some lasers, diodes, and all IPLs output square or rectangular spots - making it easy to calculate their areas.
Fluence	The fluence of a beam of light energy is the energy divided by its spot size area - in other words, the 'concentration' of energy onto the target. Higher concentrations (fluences) will usually induce greater temperature rises in the target. We quote fluences as 'Joules/square centimetre' usually (J/cm2).
Absorption	When photons of light hit atoms, they will either be absorbed or scattered. Absorption means that energy contained within each photon is 'taken' by the atom, thereby raising its vibrational state (temperature!!)
Scattering	If the photon's energy is not absorbed by an atom, then the photon will be sent on its way - usually in a different direction from its original. This is called 'scattering'. This phenomenon is important in skin teratments because it causes any light beam to spread out once it's in the skin. If you check 'fluence' from above, this means that the fluence decreases, as the light penetrates deeper into the skin.
Penetration Depth	The "useful" penetration depth of light energy is how deep it can go into the dermis while still inducing the desired reaction. This depends on the wavelength, fluence, spot size and pulsewidth.

Light, heat and the skin



Once the light energy has been absorbed by something, it is usually converted into heat energy. This increases the vibrations in the atoms, which is how we determine 'temperature'.

The trick is generating a sufficiently high temperature for an appropriate period of time, in the desired targets, without damaging the adjacent tissues. This is the core principle of 'Selective Photothermolysis' - the cornerstone of many of today's laser/IPL skin treatments.

This can be achieved by firing the correct amount of energy, over the correct time duration (pulsewidth) in the more useful spot size area (fluence) with the optimum wavelength(s).

Selecting all of these parameters properly is crucial in achieving good results. It doesn't matter which kind of light is used - lasers and IPLs deliver light energy is very similar ways. If the operator knows how to utilise their equipment properly, they will obtain the result they're after.

In addition to setting up the equipment properly, the operator must also know how to apply their light energy to the skin in a way which will maximise efficiency. This includes proper placement on the skin surface, effective skin cooling and optimum gaps between treatment session.

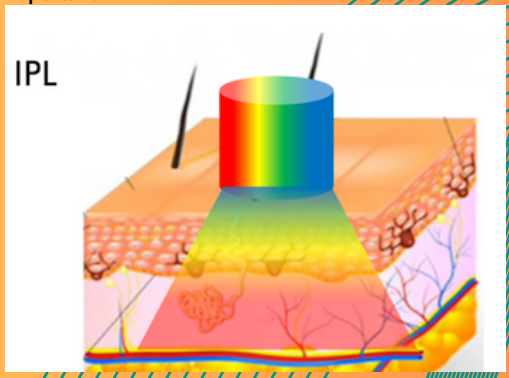
All of the above are important when considering laser/IPL treatments. Proper understanding of the processes and training are the best ways to achieve these goals.

How light energy interacts with the skin constituents is not trivial. It is, in fact, quite complicated and many researchers have studied this for decades.

All light entering the skin will encounter many, many scattering events before being finally absorbed or back-scattered out of the skin. All of these events depend strongly on the wavelength - red light penetrates much more deeply than blue light, mainly due to scattering.

Consequently, we must choose our wavelengths according to how deep the targets are. Once the light has reached our intended targets we need to maximise the amount of light energy absorption to ensure we achieve a suitable temperature increase. This means we must choose the wavelength according to the absorption characteristics of our intended targets too.

If our choice of wavelength is not good, we will never achieve good clinical results. This is why the choice of the correct wavelength(s) is so important.



Many people think that IPLs are somehow 'inferior' to lasers. This is a myth which is mostly perpetrated by laser salesmen. It is not true!

The fact is, when laser light enters the skin it rapidly loses two of its unique characteristics - the divergence and the coherence (You'll find many good articles online which describe these attributes). Once lost, the only remaining laser attribute is the single wavelength (monochromaticity).

Essentially, a laser beam becomes an intense beam of 'normal' light with a single wavelength in the skin - it is not a 'laser' beam any more. Just like IPL light!

How to treat hair

01 The Basics

There are some basic fundamentals to consider when treating hair with light-based devices such as lasers and IPL systems. It is important to understand these basics before embarking on a treatment, otherwise you may not achieve the best possible results...

02 The light

Essentially, we fire light energy into the skin. A small fraction of it (typically less than 10%) is absorbed by melanin in the hairs. This is converted into heat energy, which raises the temperatures of those hairs.

If we push up those temperatures sufficiently high, we can 'cook' those follicles dead! This is called 'irreversible denaturation'. This is the goal of these treatments. To achieve that goal, we must deliver the correct amount of light energy (fluence), over an appropriate time (pulsewidth) with a suitable wavelength (colour).

03 The hair

We use melanin in the hair shafts as the target for the light energy. Consequently, the hair MUST contain sufficient melanin to absorb enough energy to become hot enough for the process to work.

The hair MUST be 'dark' - light-based treatments cannot sufficiently heat blonde or grey or white hairs!!

"We canna change the laws of physics" as a great, fictional Scottish engineer once said, many years from now.

How to treat hair

FIRSTLY, WHAT ARE THE ‘CRITICAL’ POINTS?

FLUENCE
PULSEWIDTH
COOLING
SKIN COLOUR

To successfully, and irreversibly, destroy unwanted hair follicles we must apply the correct set of laser/IPL parameters with the proper technique.

But we must also consider the temperature rise in the epidermal melanin - this will occur, especially in darker skin tones, because the light has to pass through this layer to reach the follicles.

So, the epidermis will become hot too, and this will trigger the thermal pain nerves, just below the epidermis.

To minimise this thermal pain, we should apply the appropriate amount of skin cooling. This will also minimise unwanted tissue damage such as blistering and hyperpigmentation.

We recommend applying ice-packs to the skin surface for anywhere between two and six minutes, depending on the applied fluence and wavelength. Your patients/clients will love it!

You may have noticed that we didn't include ‘wavelength’ in our critical list! That’s because melanin absorbs across the whole of the visible spectrum and into the near infrared too. So, the wavelength is not so important!!

How to treat hair

FLUENCE

FLUENCE IS THE 'CONCENTRATION' OF ENERGY INTO A SPOT

Fluence, aka 'energy density', is the concentration of energy fired at the skin surface, and is usually expressed as Joules/cm2. Fluence directly determines the temperatures reached in the targets in the skin.

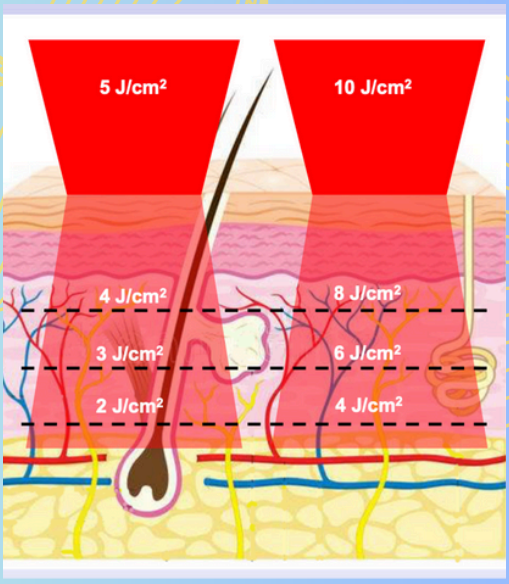
Many things in the skin will absorb light - hair, collagen, tissue water, nerves, blood etc... When they do, they will heat up as the light energy is converted into heat energy. This is usually what we are trying to do with these treatments - preferentially heat up a specific target. If we apply the correct does of light energy, we should be able to generate the right amount of heat in the desired target(s) and, hopefully, obtain the reaction we're after.

But, we must be very careful in choosing the right level of fluence - too much will destroy too much adjacent tissue and possibly create scar damage, while too little fluence will not create sufficient heat to do the job properly.

The trick is to choose the 'correct' fluence...

$$\text{Fluence} = \frac{\text{Energy (Joules)}}{\text{Spot size area (cm}^2\text{)}}$$

The fluence is absolutely CRITICAL in all photothermal skin treatments!!



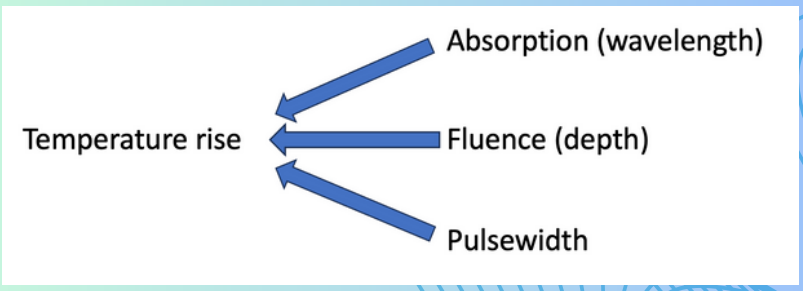
Higher fluences have a deeper effect in the skin. Deep follicles need higher fluences to ensure good results. But this also means more skin cooling must be applied to minimise unwanted tissue damage.

Do not treat over tattoos, scars or damaged skin!

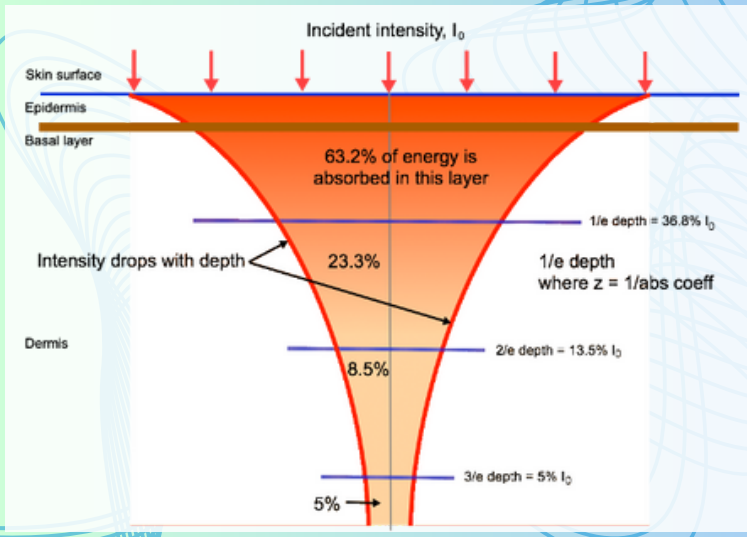
Most treatments 'fail' because the targets are hit with insufficient fluence leading to low temperatures in the hairs.

Fluence drops rapidly with depth - so we must compensate for this.

Consequently, deep targets require higher fluences to ensure the required temperatures are attained.



The point of these treatments is to push up the temperature of the targets so that they 'cook', irreversibly. In hair follicles, we need to cook the stem/germ cells sufficiently well so that they cannot regenerate the follicle when it goes back into the anagen phase of the growth cycle (see later in this booklet).



The success of all photothermal treatments depends strongly on the fluence used. Higher fluences will result in more successful outcomes, but it also means we need to cool the skin more too, to minimise epidermal damage! Photothermal treatments are, in essence, a balance between heating and cooling.

There are three main issues to consider when choosing the fluence - the maximum depth of the target, the absorption (coefficient) of the target and the pulsewidth (see next section).

All of these will influence the final temperature rise in the target.

The image on the left shows how rapidly the fluence drops with depth - it is exponential. This poses a serious problem...

Deeper targets will receive much less light energy than superficial ones. These are more difficult to destroy.

Likewise, we must choose an appropriate pulsewdith, otherwise the targets will not be sufficiently hot.

Many poor results are caused by the incorrect choice of the fluence and pulsewidth.

Fluence → Temperatures → Success

Incidentally, 'fluence' and 'fluency' are two different things...

How to treat hair

PULSEWIDTH

PULSEWIDTH IS HOW LONG THE LIGHT ENERGY IS APPLIED TO THE SKIN

Pulsewidth	Applications
Nano or picoseconds	Tattoos Pigmentation Skin rejuvenation
Milliseconds	Hair Blood vessels Pimentation Skin rejuvenation
Seconds/minutes	Skin rejuvenation

The choice of pulsewidth is a critical part of the whole laser/IPL process. It determines whether the reaction will proceed as we require, or not. If it's too short, we may not achieve sufficient 'cooking' of the targets - if too long, we may damage too much tissue (burnt!!!).

But it's a wee bit more complicated than that...

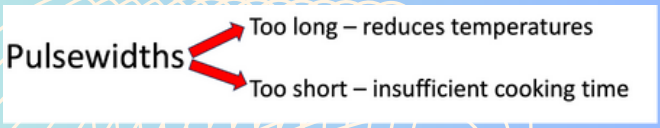
The pulsewidth has a very important effect on the treatment processes - for certain treatments such as tattoo removal, we must deliver the energy very quickly to minimise any loss of heat from the targets. So, we use extremely short pulses - typically nano or picoseconds. 1 nanosecond is a billionth of a second, while a picosecond is even shorter.

By doing this, we ensure that the temperature rises are very high - hundreds of degrees, usually. This generates the steam reaction we are after in tattoos (see the 'Tattoo' section).

In laser/IPL hair removal we must employ millisecond pulses. These deliver the fluence in such a way that the desired temperatures are attained and a sufficient 'cooking' time is applied to the germ/stem cells.

Imagine you wanted to boil an egg. You bring water in a pan to the boil - that's the 'fluence'. If you placed an egg in this boiling water and removed it after only 20 seconds, most of it would be uncooked. Only the outer region of the albumin (white) of the egg would be denatured. A 20 second 'pulsewidth' is clearly not enough! We know that boiling an egg properly needs around 3.5 to 4 minutes. It is precisely the same with hair follicles - they must be 'cooked' for the right time to ensure germ cells are fully denatured. By doing this, those follicles will not regrow.

Permanent hair removal is entirely possible using lasers and IPLs - if they are applied correctly.



For hair removal, the pulsewidth is not as important as the fluence. If the fluence is sufficiently high, then the pulsewdith becomes almost trivial. However, may laser operators use too low a fluence where the pulsewidth becomes more critical.

A particular problem exists with diode lasers. These come in a large range of output powers, which confuses many people. A 20 J/cm2 fluence from a 1000 Watt diode laser will not generate the same results as exactly the same fluence from a 5000 Watt diode. This is because the 1000 W laser delivers that fluence over a pulsewidth five times longer than the 5000 W laser!!! During that extended pulsewidth, much of the heat energy is lost to the surrounding skin, thereby lowering the maximum temperature increase.

This issue is not so much of a problem with other devices - it is peculiar to diode lasers!

How to treat hair

SKIN COOLING

COOLING – BEFORE AND AFTER – THE TREATMENT IS CRITICAL

When you think about it, we are deliberately trying to 'burn' the hair follicles. We are inducing high temperatures in them, to effectively kill them so they cannot regrow. That is the point of these treatments.

But this will also generate high temperatures in other parts of the skin too - especially in the melanin in the epidermis. This leads to pain (the pain nerves trigger at 45C) and possible blistering and hyperpigmentation.

To counter these issues, we must apply sufficient skin surface cooling before the application of the laser/IPL energy.

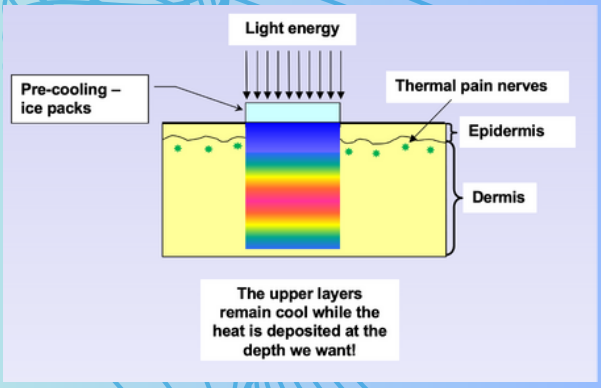
Pre-cooling

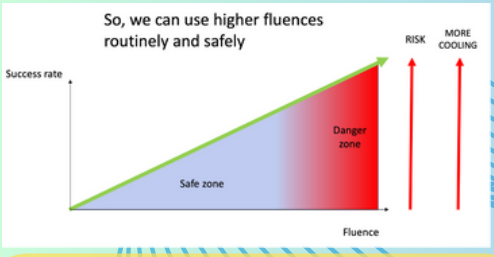
If the temperature of the pain nerves is reduced significantly (by more than 20C) then when they become hot, due to the adjacent epidermal melanin absorbing some of the light energy, their temperature will need to be raised by 30C, or more, to trigger the pain sensation. This makes the whole process much more comfortable for the patient/client, and reduces the likelihood of unwanted thermal damage.

Post-cooling

A quick calculation shows that less than 10% of the light energy we fire at the skin surface is actually absorbed by the hair melanin. A significant chunk is lost to back-scattering out of the skin altogether. But this still leaves a substantial amount of light energy in the skin, looking to 'cook' something...

We must try to remove as much of this excess heat energy as quickly as possible, to minimise unwanted tissue damage in the collagen. For this reason, we should apply surface cooling immediately after the treatment. It is best to apply ice packs onto each area as soon as that area has been treated.





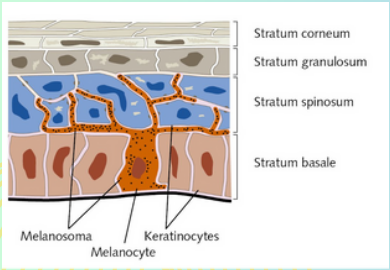
More cooling means we can apply higher fluences safely - leading to better results...

Clinical tests have clearly shown the huge benefits of pre- and post-cooling during laser hair removal treatments. Not only are they much more comfortable for the patients/clients, they also reduce tissue damage.

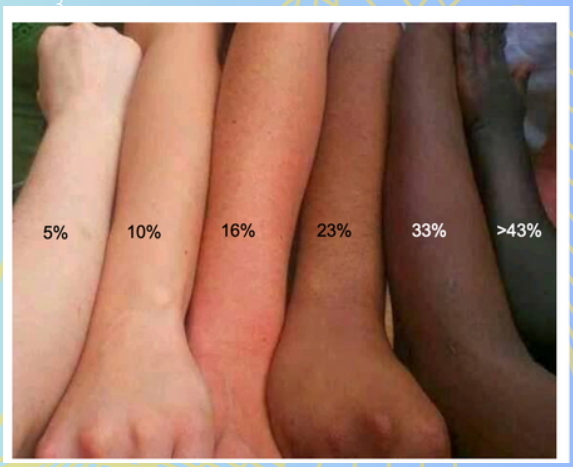
How to treat hair

SKIN COLOUR

THE SKIN COLOUR DETERMINES THE AMOUNT OF PRE-COOLNG



Skin colour comes from the concentration of melanosomes, which are created by melanocytes in the basal layer (stratum basal) of the epidermis.



Darker skins have a greater concentration of melanin - from around 5% in Skin Tone 1, up to over 43% in Skin Tone 6. As a direct consequence, darker skins will always become hotter than lighter-coloured skins, for the same applied fluence.

The 'Fitzpatrick' Scale

Dr Fitzpatrick was a dermatologist based in San Diego, California in the 1970s and 80s. He mostly dealt with skin cancer patients and developed a 'scale' to determine the likelihood of a person developing skin cancer.

His scale is based on the reaction of skin to ultra-violet light energy (which we never use in hair removal treatments).

Some bright spark in the medical laser industry 'hijacked' his scale back in the 80s and decided it could be used to determine skin 'colour' - it can't!!

Your skin colour depends on the concentration of melanosomes, at the time it is viewed! Its 'Fitzpatrick' is irrelevant!!! Red laser/IPL light does not correlate with ultraviolet light.

Darker skins MUST be pre-cooled more than lighter skins.

We prefer to use a 'Skin Tone' method to help determine the skin's colour.

Using the numbers in the above image, we can choose a Skin Tone based on the melanin concentration, *at the time of treatment* - naturally, this tone can vary across a person's body (all the time!), and can vary depending on exposure to UV light from the sun or a sunbed.

The skin tone essentially indicates how hot the epidermis will become when exposed to laser/IPL light energy. This then informs us how much pre-cooling we should apply before delivering that energy.

How to treat hair

FOUR FINAL MESSAGES

Fluence ⟷ Hair depth

Skin cooling ⟷ Skin colour

As fluence ↑, cooling must also ↑

and

As skin colour ↑, cooling must also ↑

Pre-cooling: reduce pain

and

Post-cooling: reduce tissue damage

Fluence → Success!!!

How to treat tattoos

(C) DermaLase

Modern-day, scar-free, laser tattoo removal was originally developed in Glasgow, Scotland - in the Canniesburn Plastic Surgery & Burns Unit, in the early 1980s.

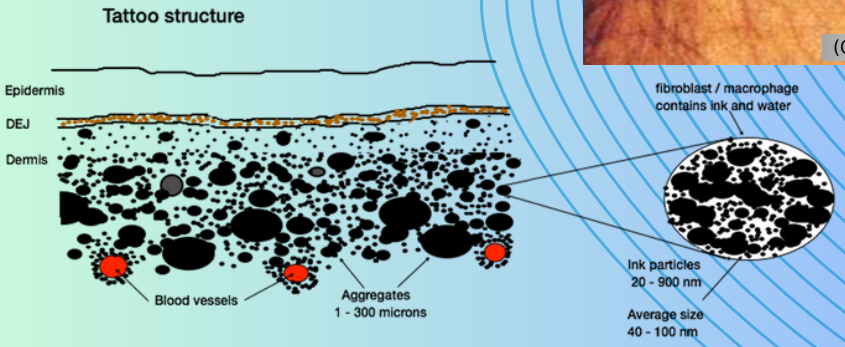
WHAT IS A TATTOO?

Before hitting them with lasers, it might be a good idea to understand what we're dealing with!

When tattoo ink is injected into the skin, there is an immediate reaction to the 'invading' ink particles. The body tries to remove the ink using lymphatic macrophages and fibroblast cells. But the tiny ink particles (around 10 to 100 nanometres in size) aggregate together under electrostatic forces. They 'clump' together into larger chunks, which become too large for the lymphatic macrophages to remove. So the body generates dermal macrophages which consume these larger aggregates and leaves them within the dermis. The ink particles exist as a 'slurry' in the cells - they do not bind together chemically.

These cells live for around 30 days before falling apart, and dying - to be replaced by new macrophages soon after. This is why tattoos become 'fuzzy' after a while.

(C) DermaLase



After about three months, all the ink particles are to be found inside dermal macrophages in the dermis. There may be a few hundred to many tens of thousands of particles inside these cells.

Top photo - before any treatment

Middle - Immediately after treatment showing frosting and erythema (reddening)

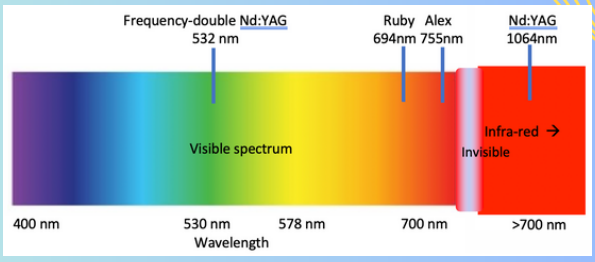
Bottom - about 15 minutes after treatment showing oedema (swelling). Note - the frosting has disappeared now

Fluence

We always advocate using relatively 'low' fluences on tattoos, Our approach is to tackle them in a 'subtle' fashion - no need to smash a nut with a sledgehammer!

Of course, the laser pulsewidth is important too - especially with tattoo removal. We must apply very short pulses in the nanosecond or picosecond range, to induce the desired reaction in the ink particles. Research shows that lower fluences are required for shorter pulsewidths.

Wavelength



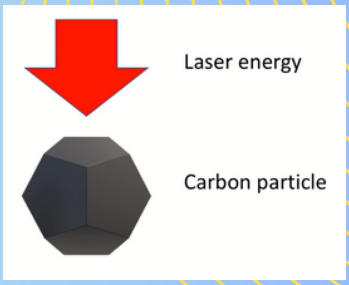
We use a range of wavelengths to tackle tattoos - matching the wavelength with a particular ink colour can help to improve results. We use the 532 and 1064nm wavelengths from the Nd:YAG laser, the 694nm from the ruby and the 755nm from alexandrite lasers.

How does laser treatment work?

This is how we think this process works...

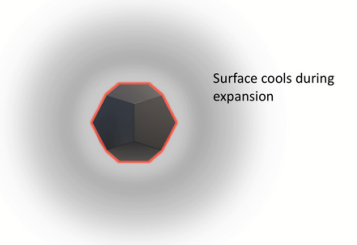
Every ink particle is contained within a cell in the dermis, and is surrounded by tissue water. The most superficial particles (near to the skin surface) absorb some of the incoming laser energy and become hot, very rapidly.

In doing so, the adjacent tissue water also becomes hot and soon forms steam (in less than a nanosecond!!!)

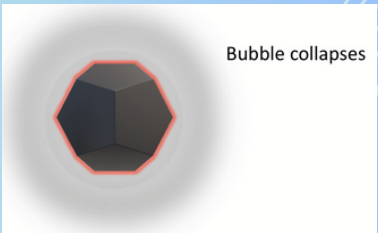


Steam bubbles expand very rapidly - up to 700 metres/second. As they do, the macrophage cells 'explode' and the ink particles are rapidly pushed into the surrounding dermis. In essence, the same conditions that existed immediately after the tattoo was originally formed are recreated by the high-speed ink particles.

This is the cause of the pain felt in these treatments - hot, sharp particles tearing through the skin and nerve tissue.

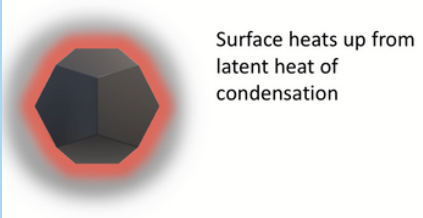


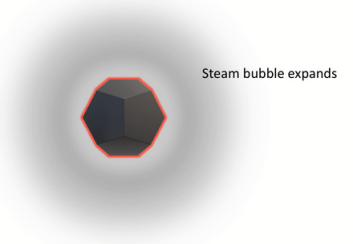
These steam bubbles effectively form a 'steam mirror' within a few nanoseconds - blocking any further absorption of laser energy. Models indicate that only a small fraction of the applied laser energy is actually absorbed by the ink particles.



After a few nanoseconds, the bubble expansion stops and it collapses back towards the ink particle. This returns some of the latent heat energy back into the particle's surface, which then re-heats, creating more steam bubbles, from condensed droplets.

This cyclic process repeats a number of times until the heat energy is finally lost to the surrounding tissues through conduction.





It appears that laser tattoo removal is essentially a steam-driven process, thanks to the tissue water surrounding all the particles. The temperatures are not sufficiently high to induce any thermo-elastic or photo-acoustic processes.

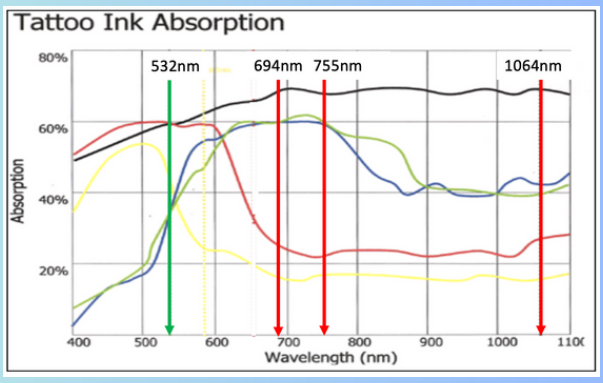
All this merely returns the tattoo particles and skin back to the same state which occurred immediately after the original tattooing process. The body then responds by kick-starting the wound response mechanisms to repair the damage and remove the ink particles.

Ink colours

There are thousands of tattoo ink colours out there today. The problem with laser tattoo removal is they all absorb different laser wavelengths to different extents. Black ink absorbs most wavelengths strongly, making it easier to shift. But some colours, such as yellow and green, absorb most wavelengths we use to a much lesser extent - making those colours trickier to remove.

Certain wavelengths are more efficient at treating certain ink colours - but it is almost impossible to accurately predict how the ink colours will respond without testing them.

Most tattoo inks also contain a lightening agent such as titanium dioxide. This pigment will reflect a lot of the incoming laser energy making those colours even more tricky to shift.



Most tattoos are composed of multiple ink colours, mixed together by the artist. This makes it quite difficult to know which laser wavelength is the 'best' option! Mixed colours will absorb the various wavelengths to different extents, leading to different rates of clearance and colour, and sometimes, chemical changes.

Number of treatments

A question every new patient asks is ‘how many treatments will I need?’ My answer is always ‘how long is a piece of string?’

It is impossible to predict this number accurately. It depends on a range of factors including:

age of the patient
age of the tattoo
health of the patient
body location
ink compositions
ink colours and depth
the time between sessions

plus a bunch of other factors. Anyone who tells you a specific number is basically guessing!!

Post-treatment care

Looking after a tattoo after laser treatment is extremely important. The laser technique essentially leaves an open wound since many ink particles can leave through the skin surface due to the explosive processes occurring in the dermis. It is, therefore, critical that the treated areas are properly cared for after each session.

We recommend applying a ‘barrier cream’ for at least 72 hours after each treatment session. Something like ‘Hydranure’, ‘Savlon +’ or ‘E45’ is good to help minimise the risk of infection, while aiding in the epidermal repair process.

How long between sessions?

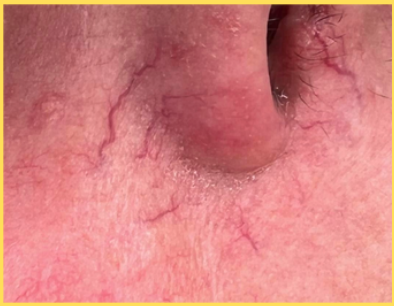
Recent research indicates that leaving around 3 to 6 month between treatment sessions allows the skin to remove more ink particles than shorter times. We must remember - the laser is not removing the ink, the body is! If we go back into the tattoo too soon, then we may not have allowed the body to remove as much ink as it might.

In essence, the longer the gap between sessions, the fewer sessions will be required overall.

Summary

Laser tattoo removal is very safe when carried out by professional laser operators with proper training. It must be approached in a subtle manner to prevent unwanted tissue damage which may lead to scarring. In many cases, all of the ink may be removed, but there are many instances when some ink is left behind. The body will continue to ‘work’ on the ink, even after treatments have finished.

How to treat blood vessels

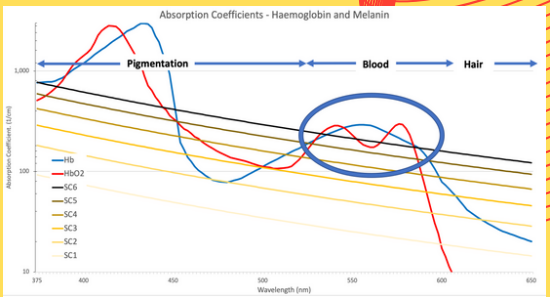


USING LIGHT ENERGY TO TREAT BLOOD VESSELS

Sometimes blood vessels expand - for various reasons. These can be very visible, particularly on the face. Fortunately, they can be readily removed using lasers and IPLs.

In this case, the optical target is the blood itself. We know that haemoglobin absorbs very strongly in the green-yellow part of the visible spectrum.

Consequently, pulsed dye lasers (with wavelengths in the range 585 to 595nm) can be used to target those vessels directly. Likewise, IPLs with filters around 530nm are also very useful.



Just as the germ/stem cells are the real targets in hair removal, in blood vessels the 'real' targets are endothelial cells which are found on the inside walls of the vessels. These cells are responsible for the enlarged nature of these vessels. If they can be 'cooked' properly, those vessels will be destroyed and new vessels - of the correct sizes - will replace them over time.

The haemoglobin in the blood absorbs the light energy, generating heat which diffuses out to the endothelial cells. If a sufficient temperature is maintained for a sufficient time, then those cells will be irreversibly denatured (cooked).

TARGETS

Using modern light-based technologies, we are able to effectively treat thread veins (telangiectasia), port wine stains, spider nevi, leg veins, rosacea, poikiloderma and other similar conditions.

But, it is very important to carefully select the 'right' targets. Some vessels are either too large or too deep to be able to treat effectively. It is difficult to treat these vessels simply because they require much more energy than many devices can deliver.

LONG-PULSED ND:YAG LASER

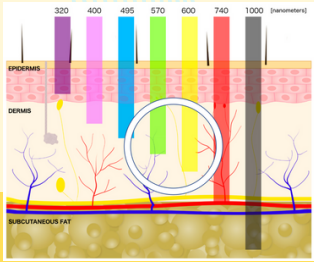
A laser which is used routinely for these treatments is the long-pulsed Nd:YAG system. These laser apply very high fluences to the skin to target vessels. However, the science indicates that they also induce significant heating of the surrounding tissues too since blood does not absorb the 1064 nm wavelength particularly strongly. But their advantage is that they can target deeper vessels due to the longer penetration depth of this wavelength and higher fluences applied.

SKIN COOLING

As with laser hair removal, applying surface skin cooling prior to the laser/IPL energy makes the whole process much more comfortable and allows for higher fluences to be safely applied.

Some people use air-cooling devices which blows very cold air onto the skin surface. Others use a cryo spray. While these are good at short-term surface cooling, they don't generate much cooling deep in the skin - that requires surface cooling applied for a suitable length of time to allow for heat to conduct out of the skin.

For that reason, we always use ice-packs from the freezer. Using these, we are confident that the skin is properly cooled before treatment. This also allows us to 'double treat' if the first application doesn't work well - we re-cool the skin for a few minutes, turn up the fluence and try again. The ice-cooling ensures we don't inflict unwanted damage to the collagen.



Blood (haemoglobin) strongly absorb in the green & yellow part of the spectrum

But these cannot penetrate as far as 1064nm

Summary

This booklet is a very brief introduction to the world of laser/IPL treatments in the skin. Here are the more salient points:

In a nutshell, it all comes down to energy! This is the stuff which drives every reaction in the skin. If you choose the correct energy coupled with the correct spot size, pulsewidth and wavelength, you will achieve your goal.

Hair

The real targets are the stem/germ cells around the follicles

Light can kill these cells only in the anagen phase - which varies significantly across the body

The hairs must be dark - i.e. contain sufficient melanin

The best situation is 'dark hair, light skin tones' - high contrast

Pre-cooling is important to minimise pain and protect the upper layers

FLUENCE is critical in achieving successful outcomes

Post-cooling is required to extract excess heat energy

Pulsewidths between 1 and 30 ms are ideal in most situations

The longer the gap between sessions, the fewer sessions will be required, overall

Too low a fluence will result in the regrowth of finer, lighter-colour hairs

Tattoos

Always be 'subtle' with tattoo lasers - use low fluences to begin with to minimise unwanted tissue damage

The desired clinical endpoints are erythema (reddening) and oedema (swelling) - nothing else is necessary!

Leave long gaps between sessions - a minimum of 8 weeks is ideal

Blood vessels

Only target superifical vessels - deep vessels may be too large and too deep to tackle

With IPLs, high fluences can remove many vessels in one session: 30+ J/cm2 in a 25ms pulse works well in many cases

Pre- and post-cooling also makes the treatment more comfortable and safer

Proper Language

The language we use to explain these treatments to clients/patients is extremely important. Often, new people will have some preconceived ideas which they have found on the Internet - often these ideas are wrong or confused!

We must convey the correct information to all clients/patients, at all times. Otherwise we will pay the price later...

'Permanent' vs 'complete' clearance

People regularly ask if they can achieve 'permanent' hair removal. This can be an ambiguous question - sometimes they actually mean 'complete' clearance and other times they do mean 'permanent'.

These, obviously, mean different things!

We are born with around 5 million hair follicles. If any die, they are not replaced. When we completely destroy follicles using light energy, they are gone forever. Hence, they are 'permanently' removed.

However, if the fluence applied is too low, then those follicles may be 'stunned', but not destroyed. The surviving germ cells may regrow, proliferate and generate a new hair in the next anagen phase. This hair will, undoubtedly, be thinner and lighter in colour. This is "*re-growth*".

Of course, all the hairs which were in catagen or telogen during treatments, will grow in the next anagen phase - this is "*new growth*".

It's impossible to tell them apart!!

There may also be dormant follicles which sit quietly in the skin until stimulated by hormonal changes, trauma or medications. These will be entirely unaffected by the laser/IPL treatments, until they begin to actively grow.

The upshot is that we CAN remove follicles permanently, if treated properly. We may also remove 100% of all the follicles in any body site, but this is a bit trickier to determine.

Complete tattoo removal

Almost every new tattoo client/patient will ask the question - "will you remove it completely?"

The truth is, we can never know. We don't know what is in the inks in anyone's skin. We do know that they are usually a mixture of a number of different coloured inks plus a lightening agent such as titanium dioxide.

This makes it very difficult to accurately predict anything!

We may be able to remove some of the ink colours, while leaving others behind. This is very typical.

There may be some ink particles which are just too deep to reach with modern lasers.

In all of these cases, we need to rely on the body's ability to remove those ink particles over time - the body is always trying to remove tattoo ink, naturally.

Another question is whether the treatment will 'scar' the area. This is always a possibility and may be due to excessive energies or simply the skin's response to the treatment. Again, this may be difficult to predict.

Blood vessels

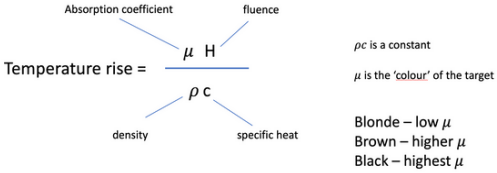
Many blood vessels may be removed using light-based treatments. But there are many which just cannot be shifted. These tend to be the deeper, and larger, vessels - we cannot get enough energy down there to do the job well.

Sometimes, we are asked if the vessels will 'return'. If they are destroyed properly, then they cannot return. However, new, enlarged vessels may appear at any time in the future. This is quite unpredictable.

Not all vessels will disappear in one session. Thicker vasculature such as port wine stains, usually require a number of repeat sessions.

Technical Stuff...

Laser-IPL interactions in the skin are actually quite difficult to figure out. There is over 40 years of theoretical and clinical research in this field, which Mike has contributed to. This last section will discuss, briefly, some of the science.



This equation explains how the temperature rises in any material which absorbs light energy

Understanding the physical processes which might occur in the skin's constituents depends very strongly on the temperature-time history, during and after the application of that energy.

The above equation tells us the instantaneous temperature rise which might occur in melanin, blood or tattoo inks, following absorption of light. However, it cannot accurately indicate the temperatures which are generated over any pulsewidths longer than around 0.1 milliseconds. To do that, we need to employ numerical models, which are quite complex.

This requires a lot of computing but can yield very useful results which can assist us in the correct choice of laser/IPL settings.

With such models, we can investigate the differences between wavelengths, pulsewdiths, fluences and techniques in various treatment applications.

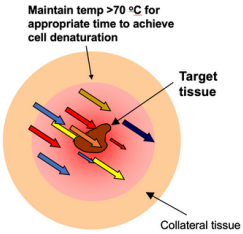
Once we have a better idea of the temperature-time histories, we can then apply them into the Arrhenius Damage Equation. This equation (see image on the right) allows us to calculate the total amount of cell damage when those cells are heated over any time period.

Of course, we need to validate our calculations with the real world. To do that, we look at a lot of clinical studies, carried out by many clinical research groups across the planet.

If our calculated predictions match those clinical study findings, then we know we are on the right track.

Mike has developed a new theory to describe the laser interactions with tattoo pigments (see Laser Tattoo Removal section). His 'steam-driven' ideas have over-turned the original 'photo-acoustic' theory, which did not have any evidence behind it.

It also explains why some colours are more difficult to remove with today's lasers. Destroying hair and blood vessels requires the denaturation of the proteins found in their germ and endothelial cells, respectively.



This means a clear understanding of the Arrhenius Damage Equation (below) is necessary.

Mike's research has revealed new and better ways to achieve good, permanent results, using a variery of lasers and IPL systems. He continues to research these processes and treatments, without external funding, meaning his work is all independent.

Arrhenius Damage Equation:

$$\Omega = A\,\partial t\,\exp(-E_a / R\,T)$$

Amount of tissue damage

Heating time (linked to pulsewidth) **LINEAR**

Tissue temperature (linked to fluence) **EXPONENTIAL**

Mike has been involved in clinical and theoretical studies since 1986 when he joined the research group in Canniesburn Hospital, Glasgow.

He has published a number of papers in medical laser journals across the world and presented many times in conferences and seminars.

With much thanks to my longtime friend and colleague PA Torstensson.

A lot more of this stuff appears in our book - see back page.


DERMA-LASE
LASER & IPL TRAINING

Mike Murphy has been investigating laser-tissue processes and treatments since 1986. He has published many peer-reviewed papers, articles and books on various topics including the removal of hair, tattoos, blood vessels, pigmentation using lasers and IPL systems.

He continues to research all of these areas and still presents his work at international medical laser conferences.

He has published three books on this subject:

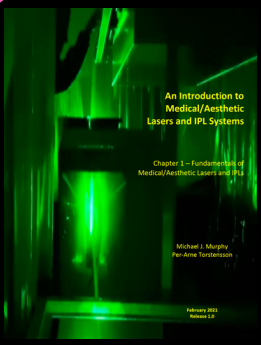
An Introduction to Medical/Aesthetic Lasers and IPL Systems

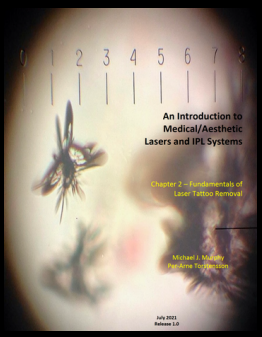
An Introduction to Laser Tattoo Removal

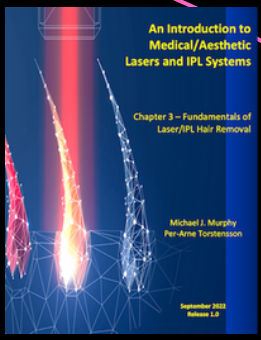
An Introduction to Laser/IPL Hair Removal

This translation was created by a machine. Our apologies if it is not quite correct.

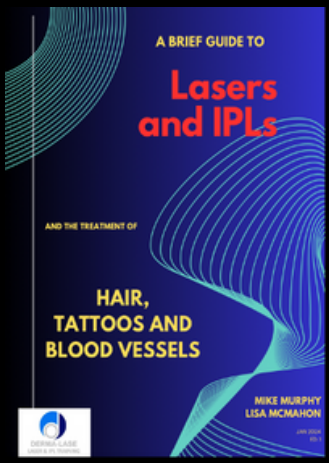
You can find his blog at '**MikeMurphyBlog.com**'

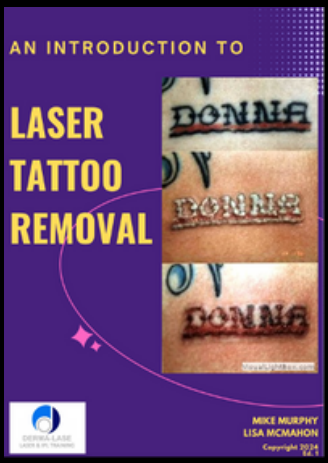


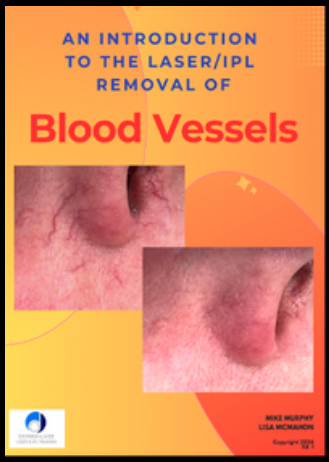




Other booklets by Mike Murphy:







Go to my blog to download these booklets at MikeMurphyBlog.com