# What is Intense Pulsed Light (IPL):

## Introduction:

Unlike lasers, intense pulsed light (IPL) systems are high-intensity pulsed sources that emit **polychromatic light** in a broad wavelength spectrum, which can differ among flash lamps and manufacturers.
The emitted broadband light is covering the spectrum from **ultraviolet (UV)** to **infrared (IR)**.
The light is filtered by various means to select wavelengths anywhere from the blue/UV through the far IR. However, the most common systems emit radiations between **400 and 1,200 nm**, with cuton and cutoff wavelengths, depending upon the indications to be treated.
The xenon flash lamp is a gas-discharged, high-intensity lamp filled with xenon gas that produces bright light when an electrical current passes through the gas. These lamps work in a pulsed mode and convert electrical energy stored in capacitor banks into optical energy.

## Mechanism:

Like lasers, the reaction mechanism of the IPL sources is based on the principle of **selective photothermolysis**. According to the thermal relaxation time, pulse duration has to fit the size of the target. The pulse durations of IPL are technically restricted to the millisecond range and should be lower than the thermal relaxation time of the target structures (chromophores) so that the surrounding tissue is not damaged.
In addition to single pulses, higher fluences can be achieved by generating burst pulses. The intervals between the pulses can be set at values between **1 and 300 ms**, which allows the epidermis to cool down between the pulses while heat is retrained in the larger targets like hair follicles or vessels.
Along with the pulse duration, the shape of the pulse is essential. Because the energy is measured over the full length of the pulse, it is important that the pulse shape is as square as possible, with instant intensity over the whole pulse duration. For a pulse duration of more than **2 ms**, the temperature obtained in the epidermis is proportional to the intensity. Therefore, a square pulse offers the lowest possible intensity for a given fluence and minimizes the risk of side effects such as skin burns. Also, a nonuniform pulse will change the spectral distribution of light emitted. Most modern systems use a sophisticated computer control system that minimizes this so-called spectral litter.
In human skin the target chromophores (hemoglobin, melanin, water) are not uniform in size and depth and show broad absorption spectrums. In addition, penetration depth increases with the wavelength in the visible spectral range. Therefore the waveband of light emitted by IPLs will be advantageous compared to lasers if the parameters of energy, pulse duration, and emission spectrum are chosen in an optimal way.

## Characteristics of IPL:

It uses an electronically controlled intense flash-lamp. For this reason, it has distinct characteristics from a laser source:

## (a) Polychromatic:

It emits a broad spectrum of wavelengths, generally in the range from **400 to 1,200 nm**. It uses **band-pass filters** placed in front of the lamp for wavelength selection. These filters remove a band of wavelengths, in general, those below the filter specification, letting through all the wavelengths above it. Some machines use a more complex filter, which narrows the emission at a range of wavelengths. Even with a narrow emission spectrum limited by the filters, the emitted energy disperse within several wavelengths, that is those that will be absorbed by the tissue to be treated and others that will have no effect. Thus, the selectivity and effectiveness of the treatment are reduced as compared with a laser that has 100 % of the energy concentrated in a single wavelength (monochromatic).

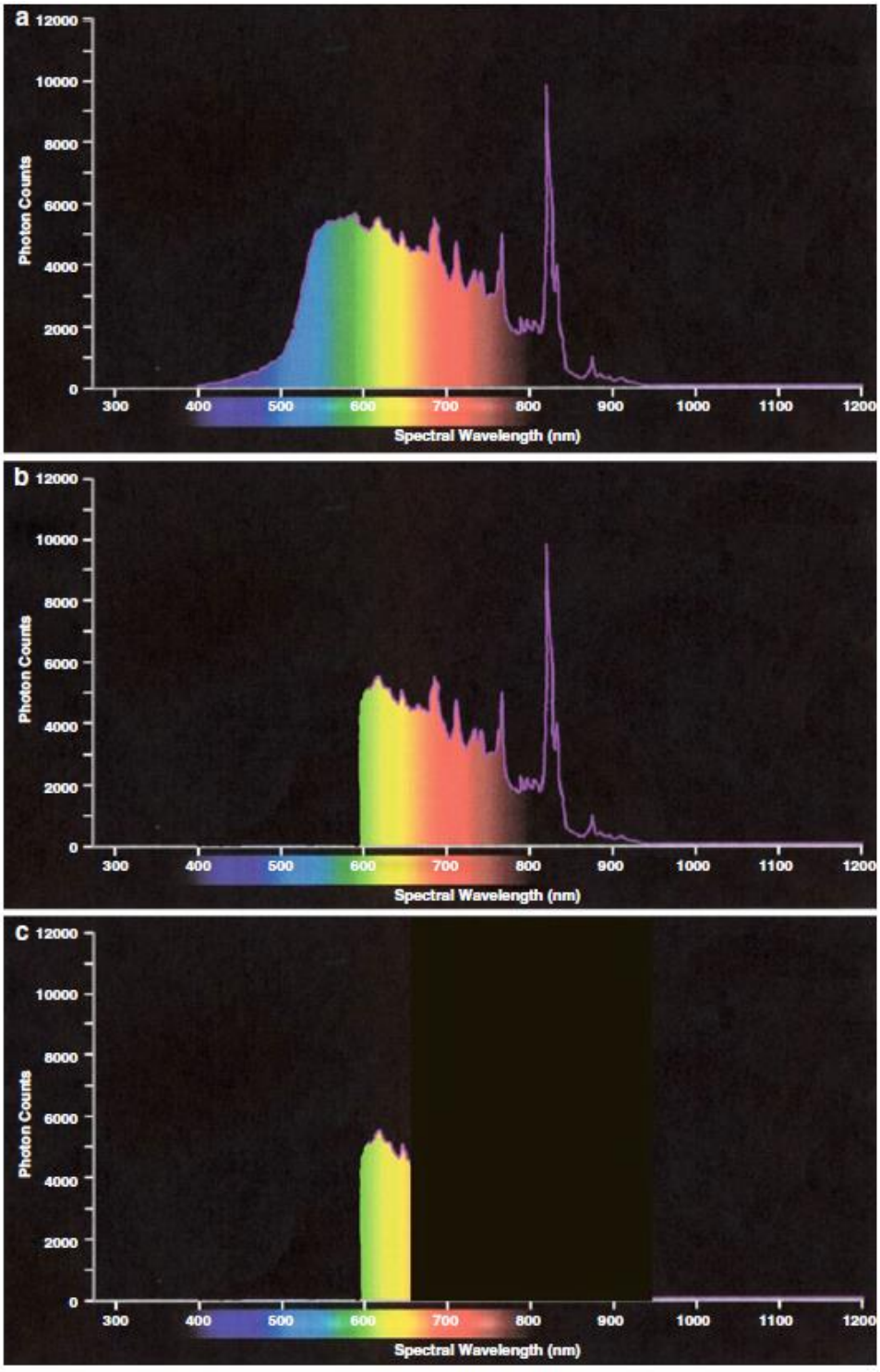


Fig. (a) General output spectrum of an IPL, (b) with a single 570 nm cut filter and (c) with a band-pass filter that limits even further the output spectrum.

(b) Incoherent:

Different from a laser source, the IPL energy is emitted in all directions; it spreads. Mirrored surfaces placed behind the lamp, similar to reflectors used in car headlights, concentrate and direct the light.It will have a more superficial and mild effect on the tissue because it is less intense than laser light. The application will also be less painful.

The multiplicity of emitted wavelengths makes these systems very versatile, being able to perform several applications such as in hair removal, pigmented lesions, non-ablative rejuvenation, and vascular lesions, by simply changing the filter and pulse duration.the application.

# Applications of IPL:

The IPL technology has evolved a great deal since its introduction 20 years ago. Today there are more than a dozen companies producing IPL systems FDA-cleared for several different dermatological treatment procedures, including vascular and pigmented lesions, hair removal, photo-rejuvenation, acne, and PDT treatments. Recently, small and still relatively effective IPLdevices for at-home-use have entered the market, allowing patients to treat themselves in the privacy of their homes.
All IPL systems on the market today are based on pulsed xenon-flash lamp emitting non-coherent, polychromatic light with wavelengths ranging from **400 to 1200 nm**.This flexibility gives IPL system the advantage of being able to perform several clinical procedures using a single system compared to lasers where a separate laser is often needed for each treatment indication.
Following are some important clinical treatment indications:

## •Reticular Leg Veins with Associated Telangiectasias:

Leg telangiectasias are visible dermal arterioles, capillaries, or veins with a diameter of 0.1–2 mm. The primary chromophores for vascular lesions are **hemoglobin** and its derivatives: *oxyhemoglobin, deoxyhemoglobin,* and *methemoglobin*. Oxyhemoglobin absorbs up to **630 nm,** while deoxyhemoglobin absorbs up to **750 nm.**
Hence, blue telangiectasias, which are more deoxygenated, are treated with light pulses between **530 nm and 750 nm.** Shorter wavelength bands are more effective in treating superficial, oxygenized red vessels but not deeper blue veins.

## • Facial Telangiectasias:

Facial telangiectasias can be classified as a linear, arborizing, spider, and punctiform. Sun exposure, steroids, and hormone replacement may play a role in development. IPL can be used to improve these telangiectasias. IPL systems have less side effects and are the patient's choice for telangiectasia treatments compared to pulsed dye laser (PDL) which leads to intracutaneous hematoma and purpura. The IPL also treats a larger surface area in a single shot **(>5 cm2)** compared to the small spot size of a PDL **(80 mm2)**. In addition, through the use of multiple pulses, IPLallows the skin to cool between the individual pulses in the pulse train and thus minimize the risk of epidermal damage.

A study showed clearance rates of **75–100%** in treating over 100 patients with essential telangiectasias.

## • Poikiloderma of Civatte:

Poikiloderma of Civatte (POC) is a condition resulting from photodamage and hence, is found on sun-exposed areas such as the *neck, forehead, and upper chest*. Skin appears erythematous, pigmented and wrinkled in appearance. IPL can be used to treat POC as the **515 nm** filter allows absorption by both the melanin and hemoglobin. Higher low wavelength cut-off filters up to **590 nm** filters may be necessary initially in more severe cases to reduce excessive light absorption and hence side effects. Studies have shown that IPL has a clearance of more than **75%** of telangiectasias and hyperpigmentation with only **5%** developing pigmentation side effects.

## • Pigmentation:

Pigmented lesions, such as *solar lentigines, congenital nevi, postinflammatory hyperpigmentation, and café-au-lait macules*, can be treated with an IPL device. The IPL device had a dual filter configuration with a low wavelength cut-off filter, water filter, and water chamber, which absorbed all infrared light and produced the desired spectrum of light when combined. Results from one session revealed a **96%** reduction in pigment, **74.2%** clearance for solar lentigines, and **66.3%** decrease in melanocytic nevi. Similarly, IPL has been examined in treating melasma. Previous studies have examined the use of IPL (**570-nm and 590- to 615-nm** filters at 4-week intervals for a total of four treatments) for the treatment of melasma and indicated that melasma improved by **39.8%** compared to only **11.6%** in the control group.

## • Photorejuvenation:

Structural components of the skin are altered due to the accumulation of UV damage. In Addition, the loss of elasticity due to normal aging can be seen on the skin. IPL is commonly used to improve signs of photoaging. Photorejuvenation through the use of the IPL device has been described as a dynamic non-ablative process used to smooth the skin surface, reduce visible vessels, and reduce mottled pigmentation. Thermal damage from the IPL device induces the formation of *type 1 and 3 collagen fibers* and reorganizes elastic fibers to improve the skin's appearance. Brief thermal damage to capillaries in the skin may induce release growth factors leading to neocollagenesis. Wavelength bands utilized range from **515** to **1000 nm** with longer wavelengths stimulating collagen synthesis and shorter wavelengths targeting pigmentation and telangiectasias.
Combination procedures, such as the use of IPL with **1064** and **1320 nm** Nd:YAG laser treatments, microdermabrasion, and the use of botulinum toxin A, may enhance photorejuvenation. Higher wavelengths from the Nd:YAG laser can stimulate collagen formation by significantly altering the dermis. IPL treatment followed immediately by a tri-chloro-acetic acid (TCA) peel is especially effective for the treatment of pigment disturbances.

## • Scarring:

There have been few studies examining the use of IPL in the treatment of hypertrophic scarring. It is hypothesized that IPL works by targeting melanin and vascular pigments which promote collagen Overgrowth. Researches show that there was a reduction in the height, erythema, and hardness of the scars.
Similarly, IPL has been used to treat **striae distensae**, a type of scar characterized by linear bands of atrophic skin.

## • Photodynamic Therapy (PDT):

PDT uses IPL as a light source which stimulates severely photodamaged skin (as in photorejuvenation) and destroys pre-malignant cells in actinic keratosis and basal cell carcinoma via activation of a photosensitizer.
The IPL light leads to the production of activated oxygen species within photodamaged cells, resulting in their destruction. Indications for PDT include **photorejuvenation, precancer and nonmelanoma skin cancer, such as actinic keratosis, superficial basal cell carcinoma,** and **Bowen's disease**. Side effects include pain during irradiation, erythema, edema, and crusting for up to a week, and subsequent hyperpigmentation, especially in darker skin types. Topical administration Of 5-aminolevulinic acid [5-ALA] or its methyl ester induces the formation of protoporphyrin IX which photosensitizers the target area prior to IPL irradiation. Depending on the photosensitizers used, treatment size, and lesion type, side effects may be more or less severe. In general, PDT is well tolerated and can be used to treat multiple areas simultaneously.

## • Hair Removal:

Studies have shown IPL has very good results in removing unwanted hair. From the study, 14 patients followed up for more than 12 months and reported **83%** of hair removal in the end. Efficacy and hence patients' satisfaction with IPL hair removal varies according to the *hair type, hair color, skin color, number of treatments, treatment settings,* and *operator*.
Black hairs on fair skin have the best hair removal clearance with IPL. However with increasing Fitzpatrick skin type, more side effects such as redness, crusting, and pigmentation changes may be seen.
Yellow discoloration of the terminal hairs and paradoxical hair growth in adjacent areas to the treated sites have been noted as side effects of the IPL treatment.

## • Acne:

Acne is a chronic inflammatory disorder of the pilosebaceous unit and is prevalent in more than 85% of adolescents. The use of light therapy for the treatment of acne is increasing due to its safety and relative efficacy. While traditional therapies include systemic and topical antibiotics, keratolytic, and retinoids, the issue of antibiotic resistance and adverse side effects may result in undertreatment, loss of patient compliance and undesired results.

It has been hypothesized that light decreases the amount of Propionibacterium and reduces the size of the pilosebaceous apparatus. More specifically, light causes photon-excitation of porphyrins present inside the bacteria, leading to the release of free oxygen radicals which are bactericidal to Propionibacterium.
Intense pulsed light devices for acne treatment release **400–1000 nm** polychromatic high-intensity pulsed light that activates the porphyrin destruction of Propionibacterium. The light also stimulates endogenous chromophores to indirectly reduce sebaceous gland activity by damaging blood vessels supplying the gland. It is postulated that IPL may also exert an anti-inflammatory effect by downregulating tumor necrosis factor-alpha (TNF-α) and upregulating transforming growth factor-beta1 (TGF-β).

## • Seborrheic Keratosis:

Seborrheic keratosis is a benign skin lesion of the epidermis which appears yellow-brown or dark-brown in color. Dermoscopy confirmed the heat-induced change in lesion color from brown to grey immediately after treatment.IPL filters with short cut-off wavelengths **(400–900 nm)** should be chosen in order to act preferentially on the epidermis and only treat the superficial lesion.

## • Sarcoidosis:

Sarcoidosis is a multi-organ systemic disease of unknown origin characterized by non-caseous Granulomas. Few studies have surfaced which examine the effect of IPL on the cutaneous manifestations of sarcoidosis. IPL treatment on the nose with a **590 nm** cutoff filter and double pulse (initial total dose 37 J/cm2) was delivered with a 20 ms delay between pulses.
It Is postulated that the mechanism of action could be due to the destruction of abnormal blood vessels, which are an important component of inflammatory dermatoses by delivering pro-inflammatory cytokines to the skin.

## • Nail Psoriasis:

Nails are a common manifestation found in up to 50% of patients with psoriasis. Nails appear with “oil drop” discoloration, splinter hemorrhages, and onycholysis. While pulsed dye laser has been used to successfully treat nail psoriasis, a study examined the effect of IPL as an additional treatment option for this condition. At the end of the study, the nail bed showed a 71.2% improvement while the nail matrix improved 32.2%. The Nail Psoriasis Severity Index(NAPSI) score also showed significant improvement post-treatment. IPL serves as a potentially promising treatment for nail psoriasis. More studies, however, need to be performed to fully examine this relationship.