
HIGH-POWER (500 W) SHORT (20-200 ms) AND LONG (40- 400 ms) PULSE DIODE LASER FOR PERMANENT HAIR REMOVAL

Mira Volvovsky, MD

ClassClinic, Sheba Medical Center, Tel Hashomer, Israel.

Abstract: Semi-conductor diode lasers with extended pulse durations have gained increasing popularity for use on individuals with darker skin phenotypes (III-VI). Based on the most recent technological and clinical needs, **MYTHOS** comprises a state-of-the-art, continuous wave (CW), powerful (500W) semi-conductor diode laser (810nm). The **MYTHOS** made significant refinements with respect to electrical engineering and biophysics that address the latest schools in hair-skin and light-skin interaction. While Msq was able to develop the most diverse, advanced diode laser, it remains user-friendly and highly convenient to operate. Furthermore, the **MYTHOS** Short Pulse (20-200 ms) and Long Pulse (40-400 ms) modes enables the clinician

wide clinical capabilities to treat different skin and hair phenotypes. The **MYTHOS** energy density per cm² may vary up to 120 J/cm², more than double compared to other high power lasers on the market. The **MYTHOS** has light weight (20Kg) table-top dimensions (20x 30x 40 cm) and can be easily transported between rooms or locations. The **MYTHOS** hand piece comes with an ergonomically-designed grip, a 12x10mm spot size, high pulse repetition rate (0.2-3Hz) and sapphire contact cooling (1-4°C) for highly safe and effective coverage rate. In addition, parallel air cooling (Cryo 5, Zimmer) can be used to provide pain-free, safe and most efficacious hair removal procedure.

Introduction

When first clinically used, laser hair removal created controversy and uncertainty. Today, lasers and light-based systems are enjoying rapidly growing acceptance, emerging as a leading core technology in the photoepilation market, with excellent safety and efficacy results. Concomitantly, an ever-growing number of new, state of the art laser and light-based devices have become available for a wide range of other cutaneous indications such as acne clearance, skin rejuvenation, psoriasis and vitiligo. Refinements in laser technology and

technique have provided patients and practitioners with more therapeutic choices and improved clinical results.

As technology matures, laser hair removal is generating growing demand not only for safe, non-invasive, pain-free, long-term hair removal, but also for efficacy, rapid pace, ease of operation, and affordable technology for the practitioner. Today, laser hair removal has become the fastest growing procedure in modern cosmetic dermatology. As more clinical experience and knowledge is being gained in the field, competition has

pushed manufacturers to seek safer and more effective technology.

Diode Laser Optics and Physics

Initial technologies for laser hair removal included the ruby, alexandrite, and carbon targeted modified short-pulse Nd:YAG lasers. These technologies although effective in treating lightly colored hairs in fair-skinned individuals, were found non-suitable for individuals with coarse, darker hair and dark skin types. Historically, the diode laser has been introduced as a device for photoepilation because of its intermediate-to-long wavelength and its very good safety profile. Today, semiconductor diode lasers are considered the most efficient light source available for hair removal. Furthermore, diode lasers with extended pulse durations have gained increasing popularity for use on individuals with dark skin phenotypes. Indications show the 800 nm wavelength to be the correct balance, offering safety on darker skin types while providing enough absorption to effectively treat finer and/or lighter hair. The 800 nm wavelength diode laser enjoys sufficient penetration depth in every part of the body, easily reaching the germinative cells located in the hair bulb (2-7 mm deep) and the bulge (1.5 mm deep) region. Because of the limited optical penetration depth typically used to reach these regions, significantly higher light doses must be applied to deposit sufficient energy at greater depths. In that respect, the pulse width underwent remarkable evolution from short (<1 ms) to long (1-1000ms) pulses, which increased the threshold of epidermal damage.

It is well established that hair removal by lasers is based on the principle of selective photothermolysis.

According to this principle, selective thermal destruction of a target (hair follicle) will occur if sufficient energy is delivered at a wavelength well absorbed by the target within a time period less than, or equal to the thermal relaxation time (TRT) of the target.

Recent studies indicate that the ideal pulse duration for medium to coarse hair reduction might be longer than the TRT of the hair follicle; short pulses with high peak power tend to ablate the hair shaft and cause damage to darker skin. On the other hand, long pulses with average peak power keep the hair shaft intact and use it as a heat radiator. Since the melanin occupies a much smaller volume compared to the follicle, heat is conducted from the shaft and melanized portion of the bulb to surrounding structures according to the laws of thermal diffusion. As more findings amassed about the mechanism of hair removal, it became evident that contrary to prior belief, the true targets for permanent hair removal are located at a distance from the hair shaft, at the outer root sheath of the follicle (stem cells) and the base of the follicle. This important observation warranted reconsideration as to the appropriate laser parameters, particularly the pulse width and energy density, required for safe and effective long-term hair removal.

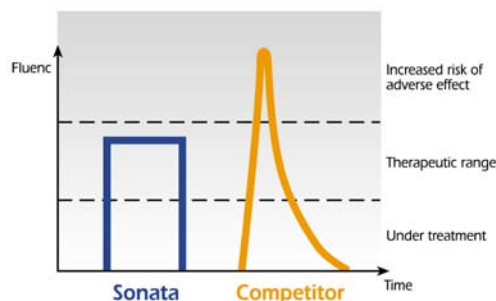
Msq has made significant technological refinements to address the latest schools in hair and skin biology, skin optics and physics with its safe, diverse, most advanced diode laser hair removal system in the market.

System Technology

The *MYTHOS* diode laser system provides permanent hair reduction using state-of-the-art, high power laser

technology. The **MYTHOS** is a semiconductor laser array emitting in the near infrared range at a wavelength of 810 nm (± 10 nm). The system is a continuous wave (CW) mode, rather than a quasi CW (pulsed) as in the case of the LightSheer (LS) system. The LS has a very high peak power – up to 2,600 watts but is limited in its duty cycle (the ratio of “On” to “Off” times). Thus the average power of the LS is low. In contrast, the **MYTHOS** is a 500 watt CW system where the peak power is the same as the average power – i.e. 500 watts.

The following graph depicts **MYTHOS** pulse shape and amplitude. The pulse is characterized by moderate peak power, and homogeneous energy distribution along the entire pulse width. These features translate into an optimal therapeutic range (fluence) and skin trauma-free procedure.



MYTHOS is a 500 watt power on tissue system. The maximal energy density per cm^2 can vary up to 120 J/cm^2 (therapeutic range $\sim 60 \text{ J/cm}^2$). Because of its CW mode and pulse morphology, the **MYTHOS** can employ higher fluence levels that are less traumatic to the epidermis and fewer post treatment pigmentary disorders when compared to existing diode technologies. The **MYTHOS** is a table-top size (20 x 30 x 40 cm) that can be portable (20Kg).

The hand piece comes with an ergonomically designed grip, a large spot size of 12 x 10mm, adjustable high pulse repetition rate (0.2-3Hz) and sapphire contact cooling ($1-4^\circ\text{C}$) for safe, fast and effective clinical results. In cases when high coverage rate (3Hz) is needed such as during treatment of large areas (back, chest and legs), a parallel air cooling adaptor (Zimmer, Cryo 5) is connected to the **MYTHOS** hand piece, that can provide virtually pain-free and most effective hair removal treatment.



MYTHOS cooling technology: Parallel air cooling adaptor (left) + Sapphire contact cooling (right).

The 1.2 cm^2 spot size allows the practitioner to accurately treat a small area at a high repetition rate of up to 180 pulses per minute! Unlike most other systems that locate the laser source in the console and passing the beam through large and obtrusive tubing, the **MYTHOS** diode laser optical bench is located inside the hand piece, making it much more efficient.

The **MYTHOS** is capable of modulating the pulse duration between 20-400msec. The **MYTHOS** gives the physician a choice of two pulse programs: “Pulse” and “Long Pulse”. The operator can choose either one of the programs or use both; in this case, the “Long Pulse” precedes the “Pulse” mode. Energy density (fluence) and its equivalent Pulse/Long Pulse widths are depicted in the following table:

Fluence Setting (J/cm ²)	Pulse (msec)	Long Pulse (msec)
10	33	66
15	50	100
20	66	132
25	83	166
30	100	200
35	116	232
40	133	266
45	150	300
50	166	332
55	183	366
60	200	400

The Pulse (33-200 msec) program fits light skin types (I-III) while the Long Pulse (66-400 msec) program fits dark skin types (III-VI). Pulse repetition rate (Hz) for a given pulse mode (Pulse or Long Pulse) or a combination mode (Pulse + Long Pulse) is automatically adjusted by the system as the fluence increases. Typical recommended fluence levels range between 35-45 J/cm². Caution should be exercised however when using the Long Pulse (>100msec) mode in dense populated hair follicles due to thermal conduction between adjacent hair follicles. The optimization and synergy of pulse widths, fluence and different repetition rates in the **MYTHOS** increases clinical efficacy while reducing the risk of epidermal damage, particularly when working on dark skin types IV-VI.

System Description

The **MYTHOS** complete system consists of a cart, a console, a footswitch and hand piece. Laser parameters and other system features are controlled from the control panel on the console, which provides a user-friendly intuitive interface with the system's operating

system. The connector enables replacement of the laser hand piece when required. The tissue cooling system (TCS) is incorporated in the hand piece to reduce the pain and protect the epidermis during contact with the beam. The TCS is automatically activated during system operation to ensure safety. The cold hand piece plate is cooled down to 1- 4°C and cools the treated area before, during and after lasing. One of the TCS's main advantages is that it allows for active cooling during exposure. Significant benefit from such "parallel" cooling is achieved primarily with the Long Pulse mode. At such Long Pulse durations, the temperature peak in the basal layer and near the skin surface is reduced, which helps protect the epidermis from nonselective thermal damage.



Pre & post treatment considerations

Prior to treatment, conditions should match the indications for skin type I-VI laser hair removal (Inclusion Criteria). Caution is advised in treating patients with keloid scarring, recent tanning, use of photosensitive medications, use of Accutane or active infections or history of herpes simplex in the treatment area. Patients with skin cancer or history of

cancer, pregnant women or patients with epilepsy should not be treated (Exclusion Criteria). For 3 to 6 weeks prior to the treatment, the patient should not wax, tweeze, bleach or undergo electrolysis on the area to be treated. Shaving can be done just prior to treatment. If at all possible, patients should not expose the area to be treated to the sun for eight weeks prior to treatment. For medico-legal consideration and in order to establish concrete visual evidence it is recommended that before and after treatment photographs should be taken.

Before the first treatment, a Skin Test must be conducted for each patient. The Skin Test should be applied on area intend for treatment. Test results should be screened 30 minutes (skin types I-III) and 24-48 hours (skin types IV-VI) after the test. If there are no noticeable changes in the hair follicles, or adverse side effects, the practitioner should increase the energy density by 2-3 J/cm². On the other hand, if adverse skin effects occur the treatment parameters should be reduced, (i.e., fluence and pulse duration) and the practitioner should change the operating mode from Pulse to Long Pulse and retest the area.

The practitioner should outline the objective limitations that exist in laser hair removal technology and set realistic expectations. Laser hair removal with the **MYTHOS** is a multi-session process that requires the patient's full compliance. Discomfort associated with the treatment is usually a sting-like sensation; however patients may be offered use of a topical anesthesia such as Ela-Max, EMLA or Topicaine. Patients should be carefully advised about typical and anticipated post treatment adverse side effects such as redness (erythema), and edema, all

transient within 4 -24 hours after the treatment. In any case of patient discomfort it is the practitioner's responsibility to treat the area appropriately. After the treatment, the patient should avoid sun exposure. In cases where sun exposure is imminent, the patient should protect the area with SPF 30 sunscreen. The patient should not use glycolic cleansers or Retin-A products over the treated area for one week after treatment. Within about 24 hours after the treatment, the patient may notice what appear to be rapidly growing hairs in the treated area; these present destroyed hair follicles ejecting from the hair follicle which can be removed gently with tweezers. Patient should not pull hairs that are firmly attached.

Application of Treatment

Prior to the treatment, the hair should be shaved. It is imperative that all people present in the treatment room protect themselves with eyewear. The System emits a single laser pulse per each press of the footswitch and the hand piece trigger. Pulse fluence (energy density) can be set by the operator, for different tissue effects. The system automatically selects the appropriate pulse duration for the selected fluence. After choosing the appropriate parameters the hand piece should be positioned perpendicular to the skin and be pressed lightly to the area. During pulsing, the Hand piece should be kept in full contact with the skin. Treatment end points are mild redness several minutes after lasing.

It is recommended to apply ultrasonic gel on the treatment area to allow more effective and comfortable results. The practitioner should maintain homogenous, continuous and qualitative passes with intermittent treatment head lifting and repositioning of the head.

Overlapping should be ~ 10%. In order to keep the head clean and avoid external untoward burns to the skin, the head should be cleansed with an alcohol pad intermittently during and after the treatment. At the conclusion of the treatment it is recommended to cool the area immediately with frozen pad gauzes to reduce swelling and ease discomfort. Biafine or Aloe Vera cream emulsion is also recommended and should be applied 24-72 hours post treatment.

Clinical Results

Clinical experience with the **MYTHOS** has demonstrated high degree of safety and efficacy in patients with skin types I-VI. In both genders, treatments in the bikini line and axilla areas resulted in clearance rates of > 80% after only 3-5 treatments. These results persisted also after 6 months. Similarly, in the face, back, trunk sides and legs clearance rates were between 70%-80% after only 4-6 treatments. Typically, the end-points of perifollicular and/or epidermal erythema will appear 10-15 minutes post-treatment. Patients have tolerated the treatment with minimal discomfort, and no acute epidermal or dermal damage was reported during or following multiple treatments for all skin types. To validate the **MYTHOS** safety claim we have conducted side-by-side comparison of a single treatment with the **MYTHOS** (right upper back) when compared to LightSheer (left upper back). The end points of each single treatment are documented in the following photographs. It is clearly seen that the LightSheer caused significant skin reaction/trauma when compared to the **MYTHOS**. From our clinical experience, in addition to excellent clinical results, the non-traumatic skin response translates to reduction in post treatment

pigmentary disorders. In summary, the **MYTHOS** provides safer and most effective temporary and permanent reduction of pigmented hair in skin types I-VI.



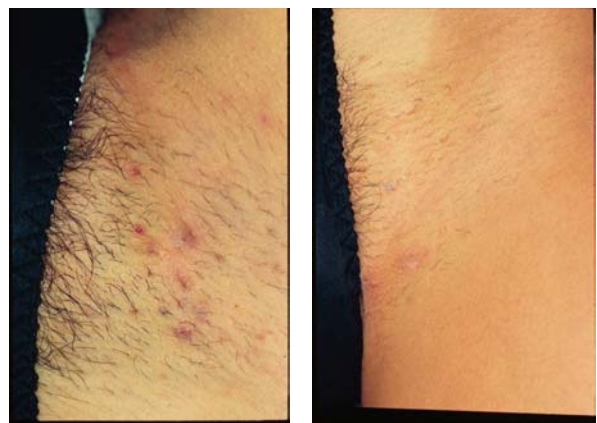
Parameters: 24J/cm²; 30 msec

End Points: Diffused erythema + edema



Parameters: 24J/cm²; 80 msec

End Point: Mild erythema



Bikini: 6 months after 5th treatment. (Photos are courtesy of **Dr Brown** and **Prof. Orenstien**).