

Introduction to Nanotechnology

- Textbook :
Nanophysics and Nanotechnology
by:
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Classroom: A209
Time: Thursday; 13:20-16:10 PM
Office hour: Thur., 10:00-11:30 AM or by appointment

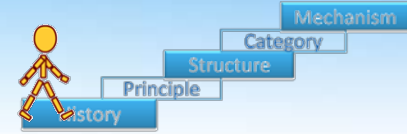


Microsoft®
Silverlight™

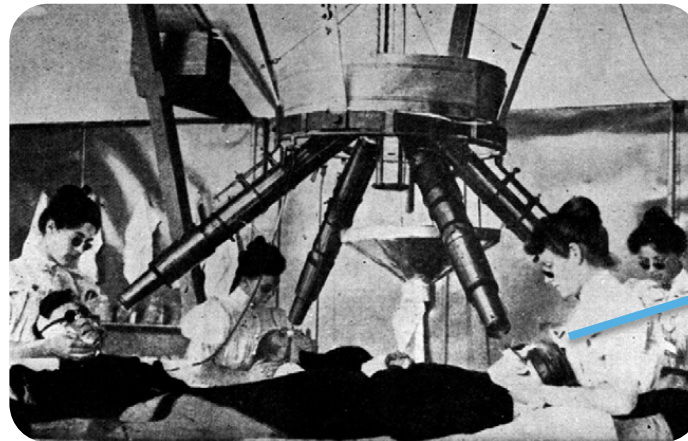


Light-Emitting Diodes (LEDs)

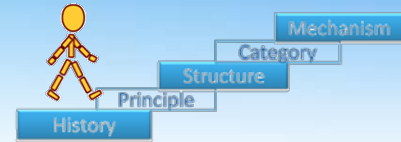
Light Therapy History



- Thousands of years ago → Used to treat skin diseases.
- 1903, Niels Ryberg Finsen (Nobel Prize) → Treatment of diseases, notably lupus vulgaris.

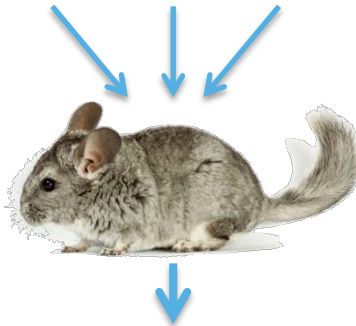


Light Therapy History

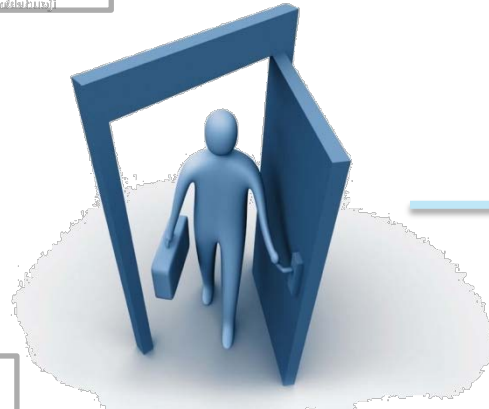


- Late 1960s → Endre Mester

Low-level laser therapy (LLLT)



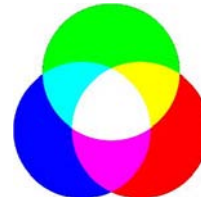
~~cancer~~
regeneration



**LED
Therapy**
(Light-emitting
Diodes)

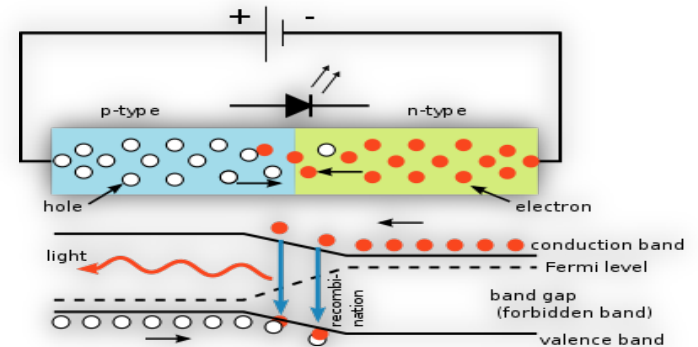
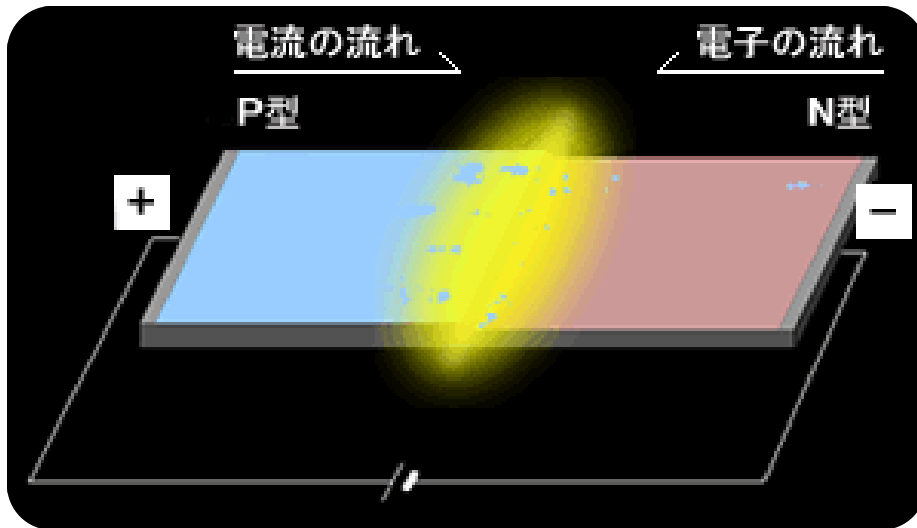
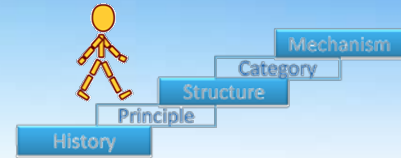
- 1993 → Nichia

1. Producing **blue** LEDs
2. Producing **white** light LEDs (RGB)



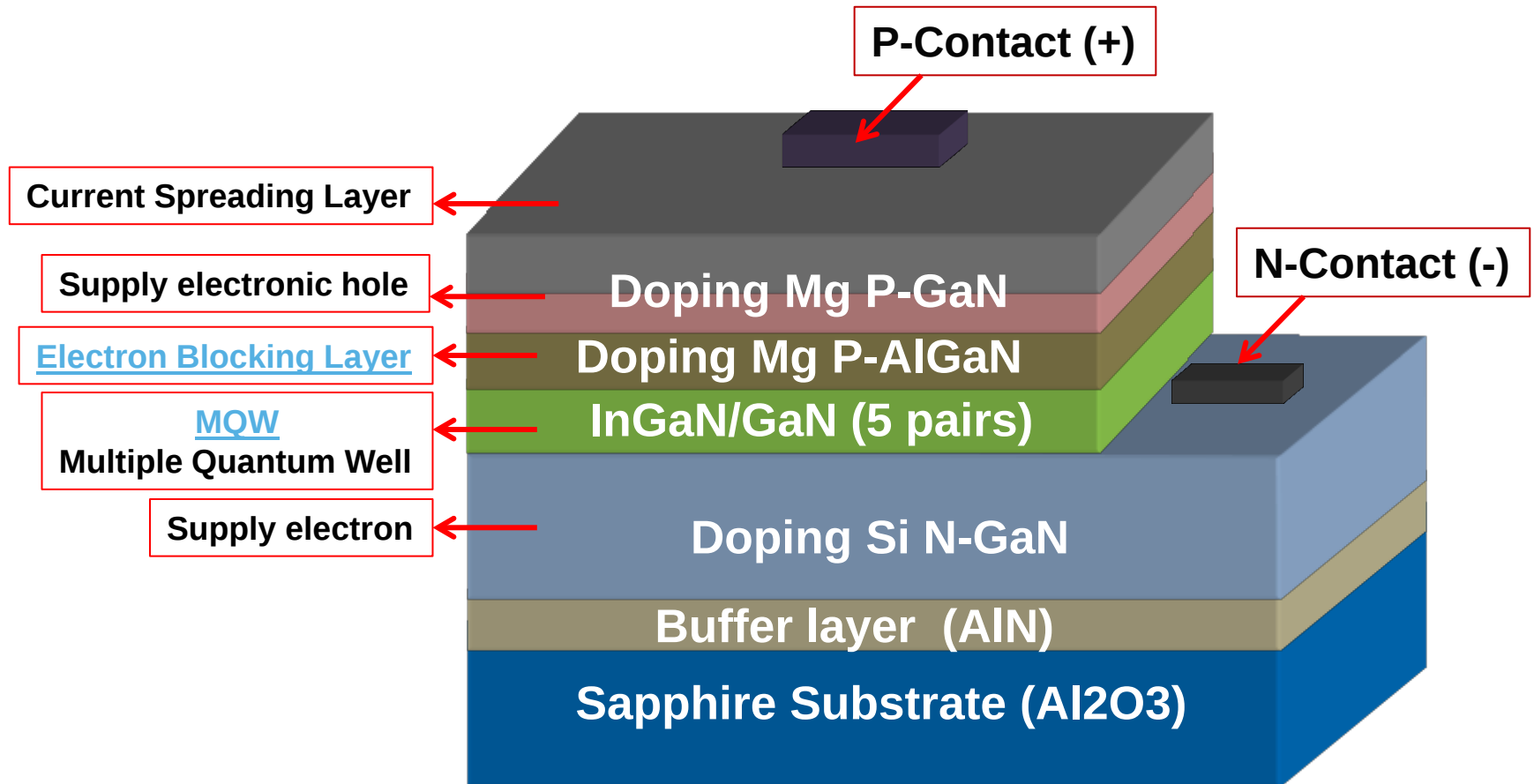
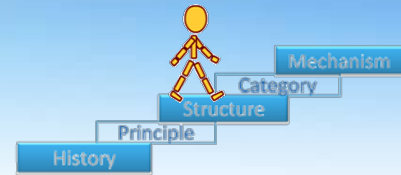
**LED
Industry**

Principle



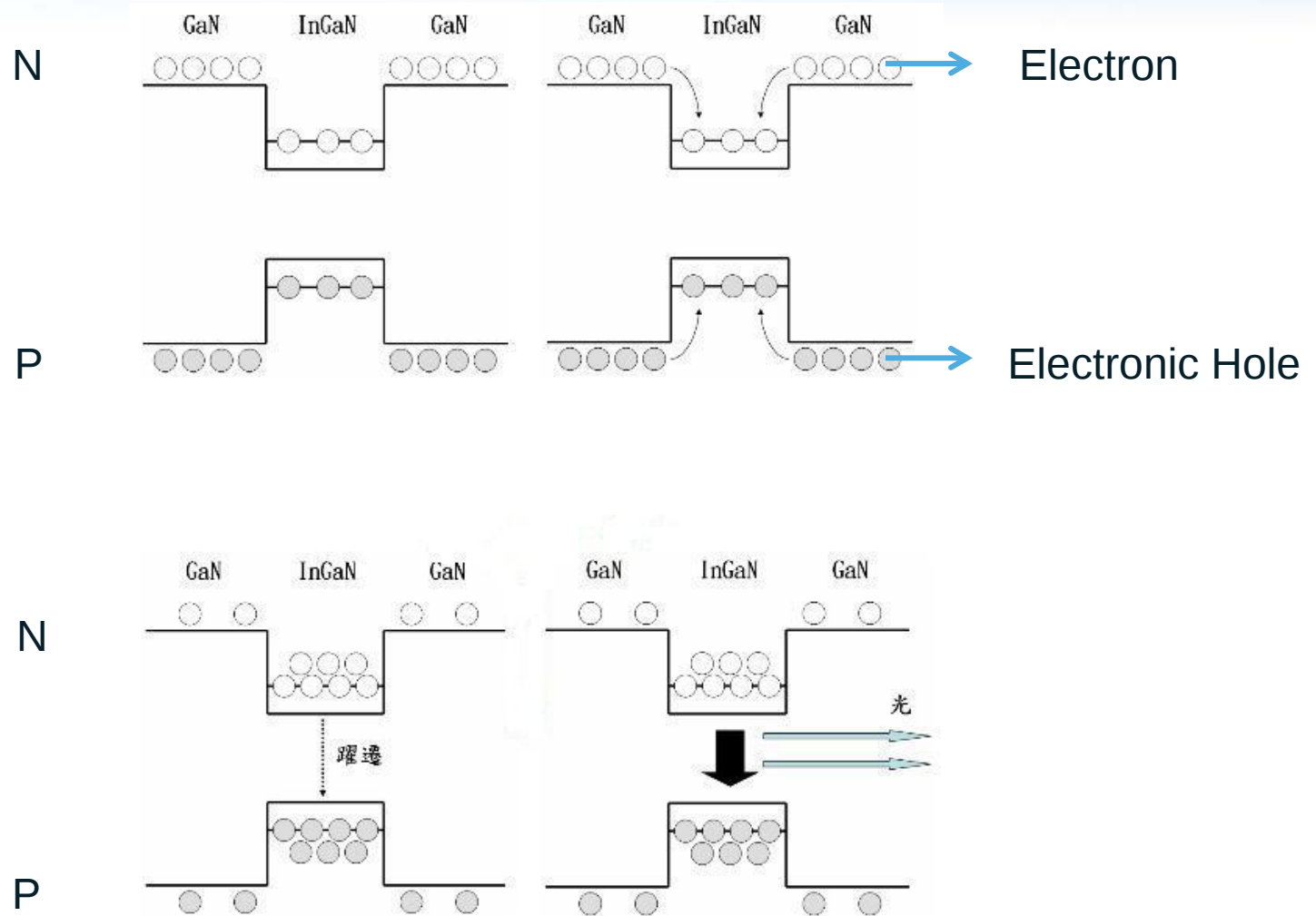
Current flow from P to N.
When an electron meets a hole,
it falls into a lower [energy level](#),
and releases [energy](#) in the form
of a [photon](#).

LED Structure



MQW

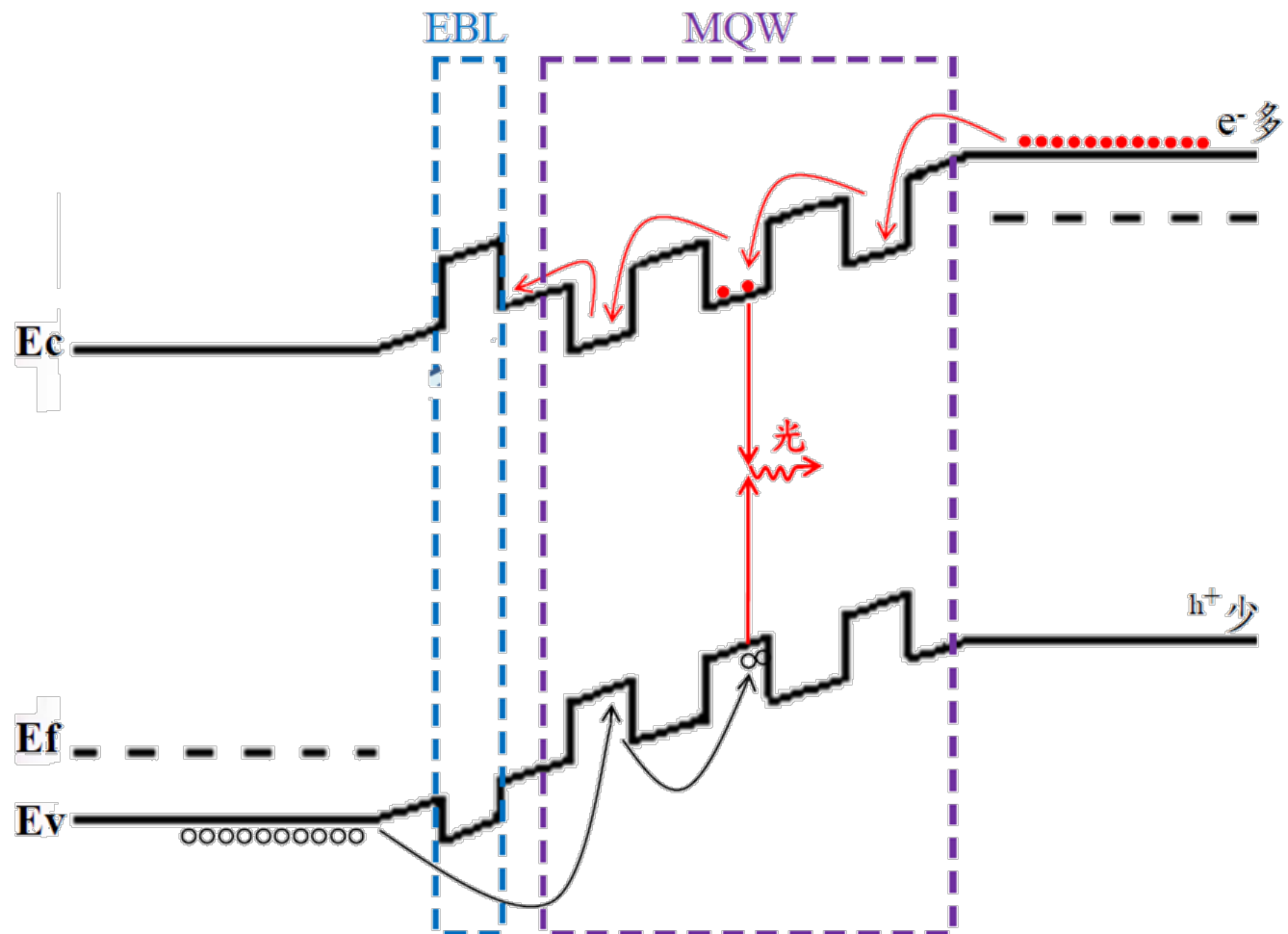
Multiple Quantum Well



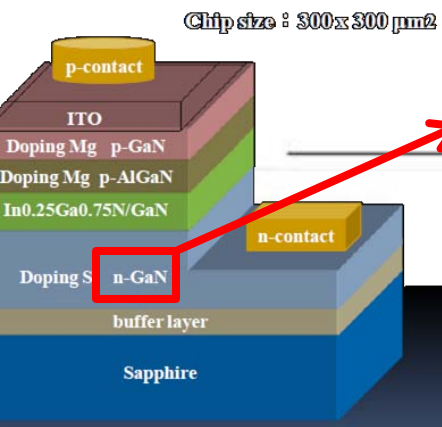
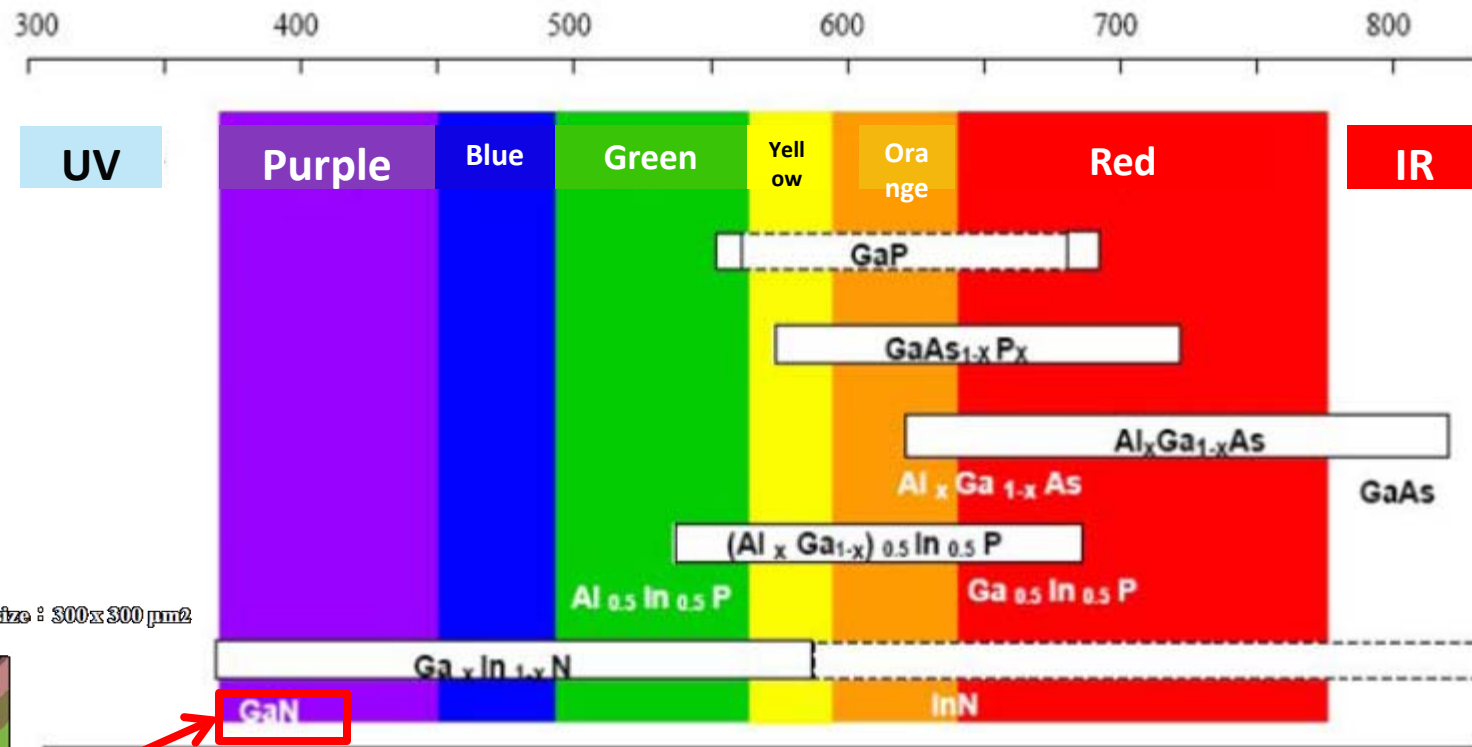
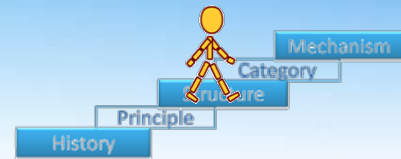


EBL
Electron Blocking Layer

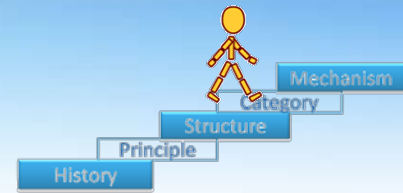
MQW
Multiple Quantum Well



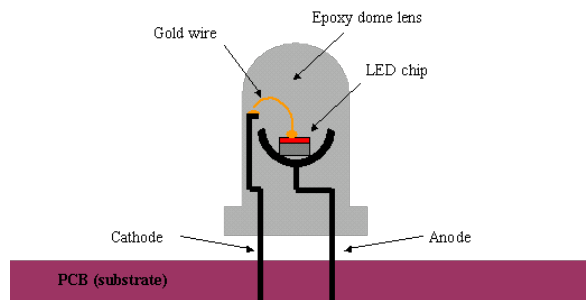
LED Structure-Material



Category



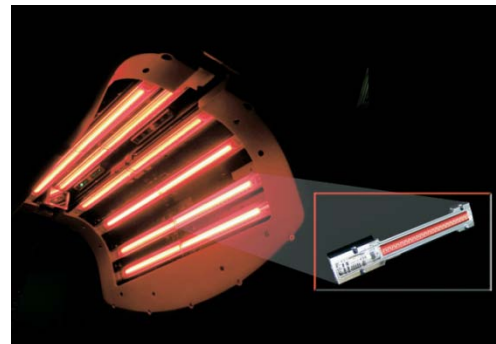
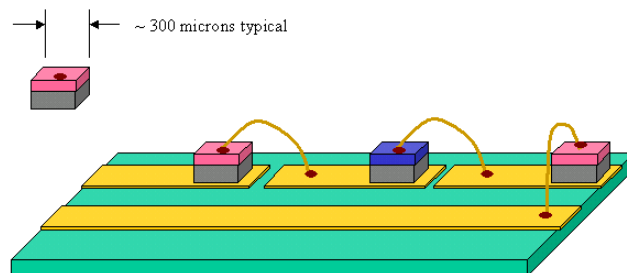
1. Packed LED



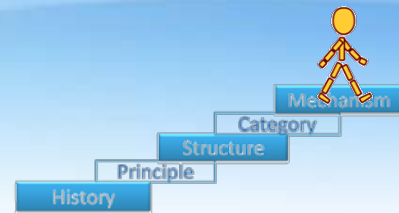
Disadvantage :

1. No sufficiently uniform lighting
2. Not Well heat-sinked

2. Chip-on-board



Mechanism of Action

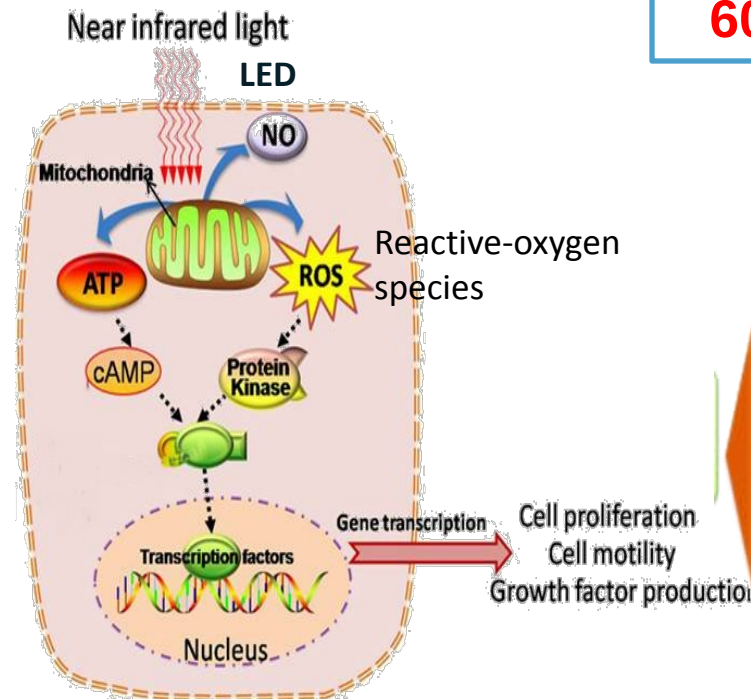


LEDs can trigger natural intracellular photo-biochemical reactions

**Optimal
parameter
600-1000nm**

Hypothesis

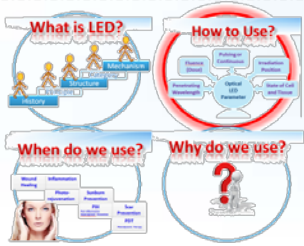
1. Mitochondria Mechanism
2. NO Mechanism
3. Redox Mechanism



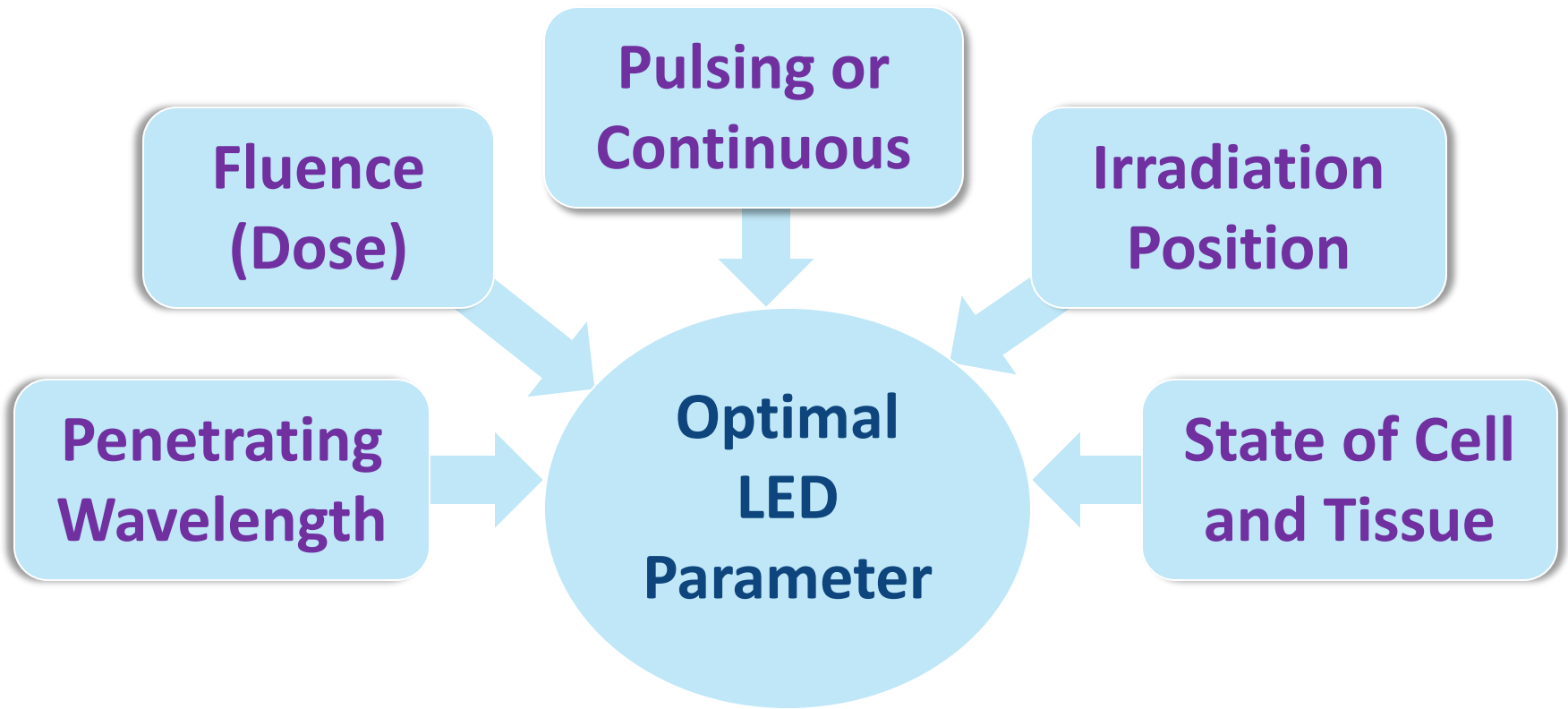
Wound Healing
Tissue Repair
Tissue Death
Prevention

Inflammation
Pain Relief
Edema
Acute Injuries
Chronic diseases

Neurogenic
Pain
Neurological
Problems
Acupuncture



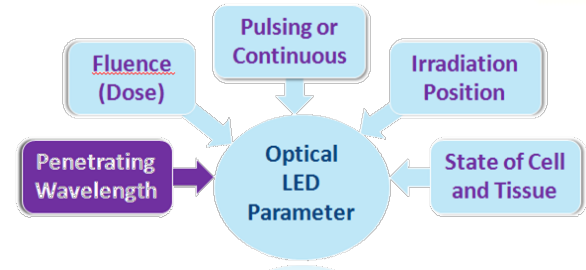
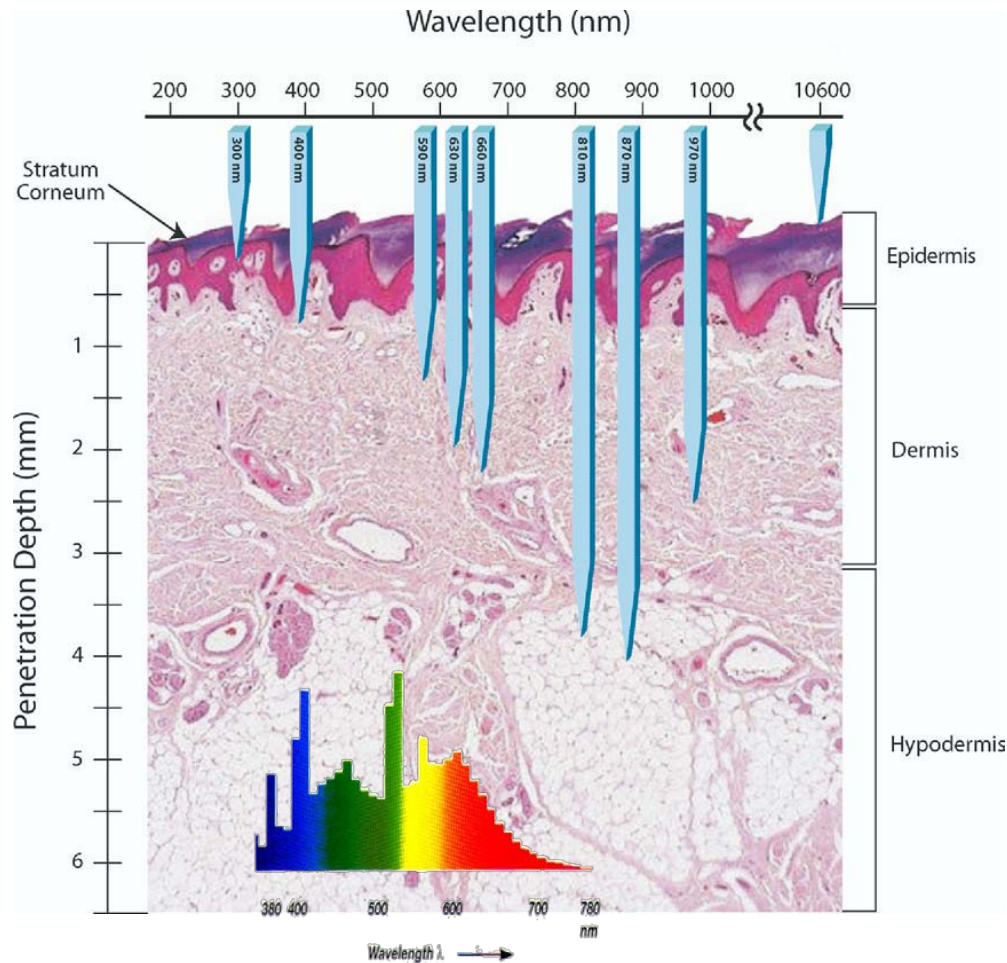
How to Use?



Optimal LED Parameter

600-1000 nm

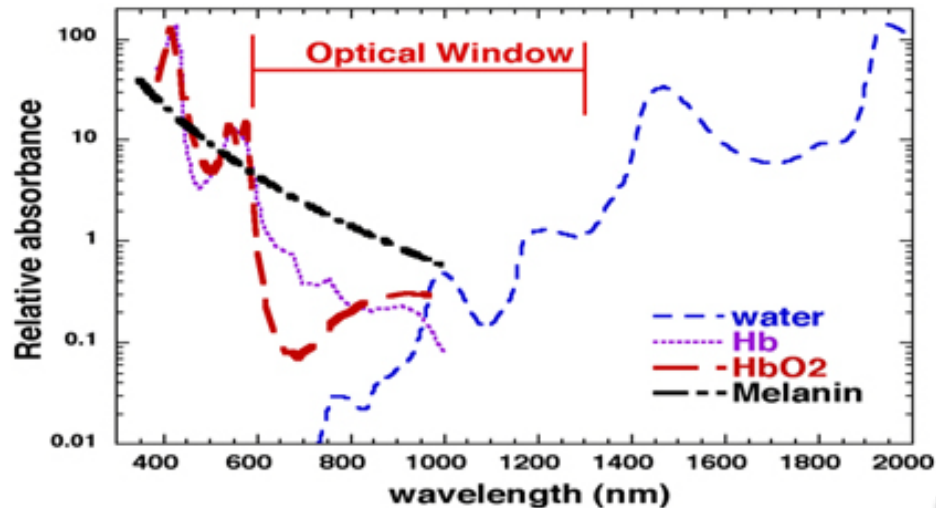
1. Penetrating Wavelength



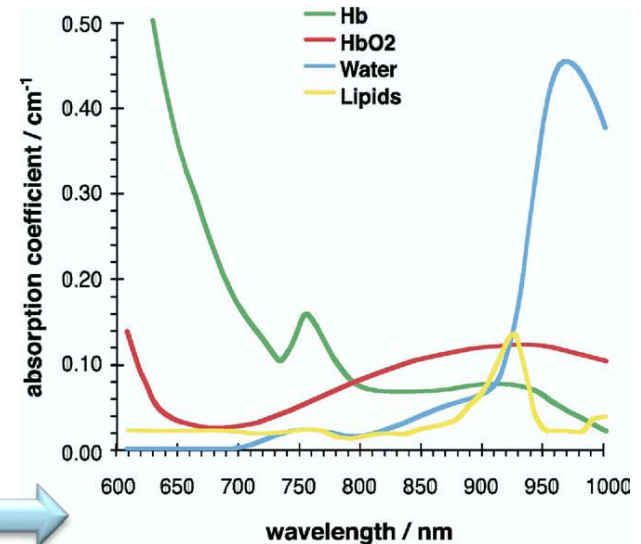
The longer the wavelength, the deeper the penetration into tissues.

Collar	Wavelength
Blue	400-470 nm
Green	470-550 nm
Red	630-700 nm
NIR	700-1200 nm

Optimal LED Parameter



< 600 nm : Hemoglobin and melanin have high absorption bands.
> 1000 nm : Water is also absorbing many photons, reducing their availability for specific chromophores located.



**Optimal
parameter
600-1000 nm**

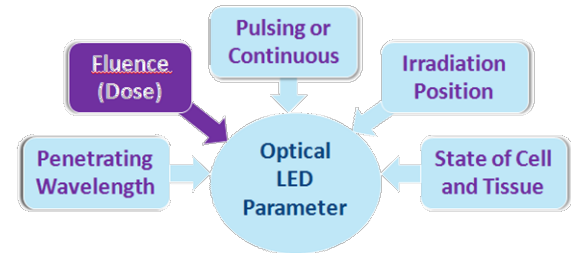
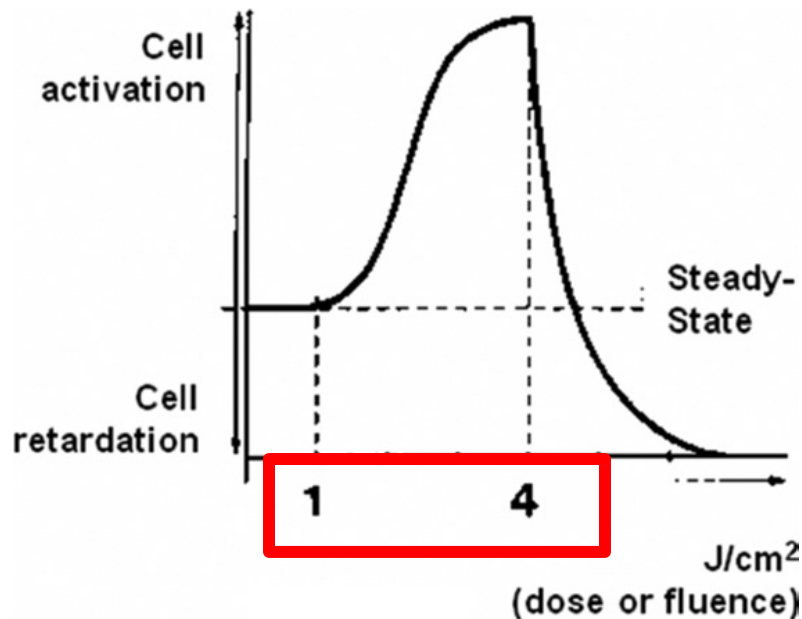
Optimal LED Parameter

1-4J/cm²

2. Fluence and Irradiance

Dose = Intensity X Time

J/cm² = W/cm² X S



Arndt-Schulz law

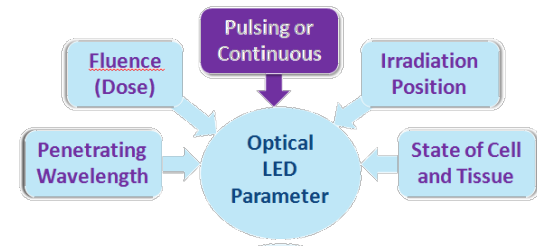
- Weak stimuli accelerate physiologic activity
- Medium stimuli inhibit physiologic activity
- Strong stimuli halt physiologic activity

Optical LED Parameter

Pulsing

3. Pulsing and Continuous Modes

Ultra-short pulses can travel deeper into tissues than CW radiation.



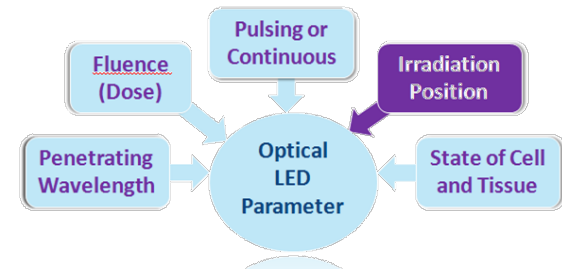
The first part of a powerful pulse may contain enough photons to take all chromophore molecules in the upper tissue layer to excited states, thus literally opening a road for itself into tissue.

Optical LED Parameter

Precise

4. Irradiation Positioning

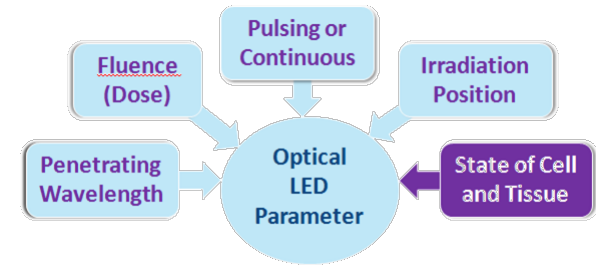
Amount of energy must be delivered to the target to trigger the expected cell response.



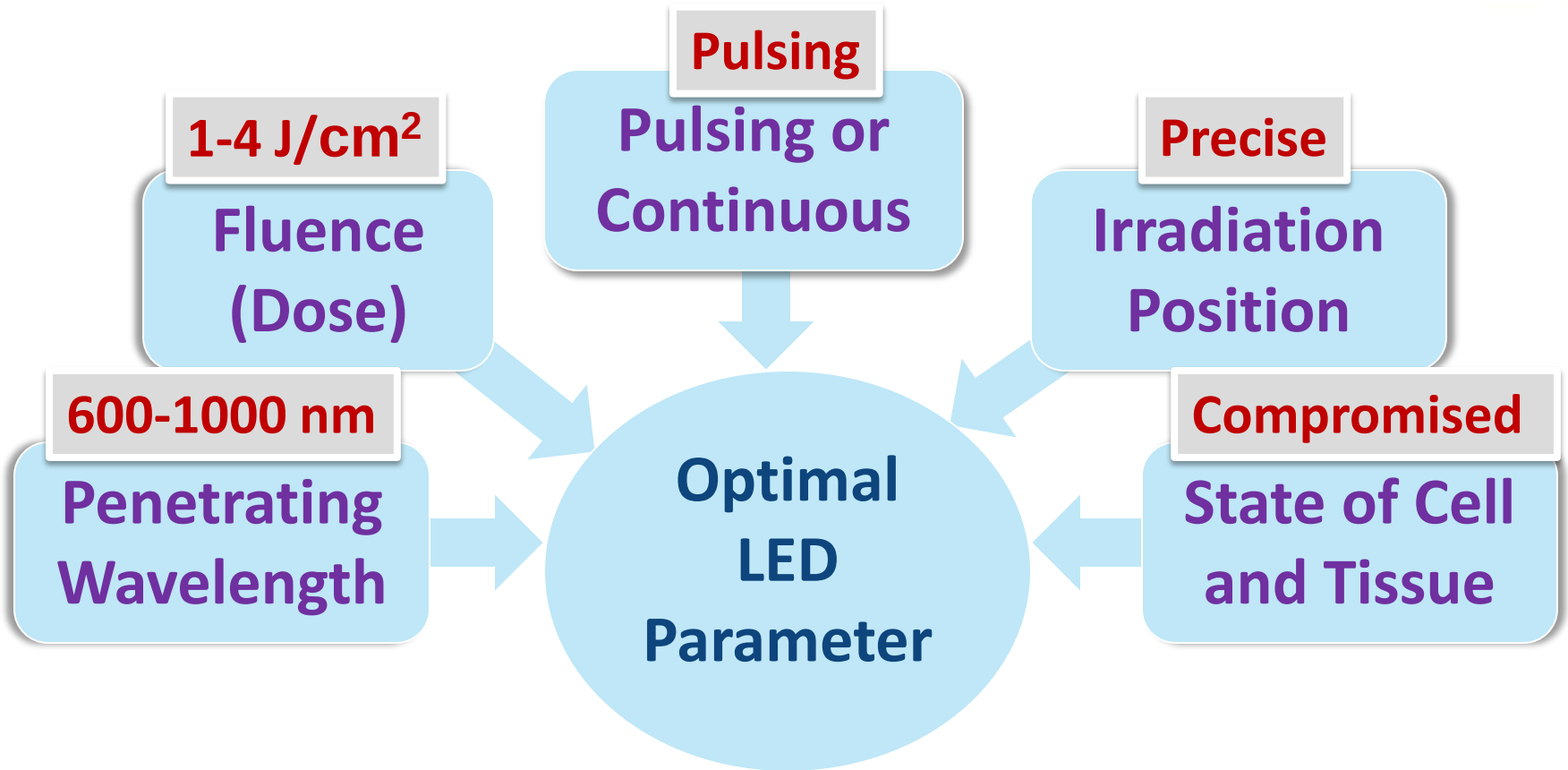
Compromised

5. State of Cells and Tissue

Compromised cells and tissues respond more readily than healthy cells or tissues to energy transfers that occur between LED-emitted photons and the receptive chromophores.

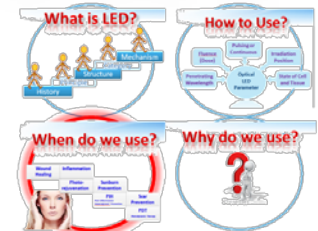


Optimal LED Parameter



When do we use?

4 Questions about This Paper



**Wound
Healing**

**Anti-
Inflammation**

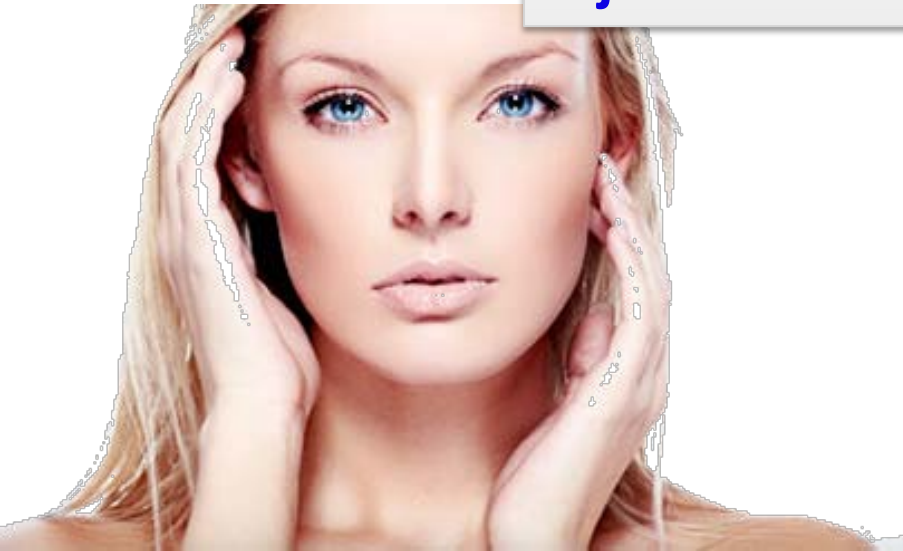
**Photo-
rejuvenation**

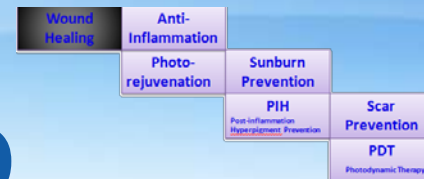
**Sunburn
Prevention**

PIH
Post-inflammation
Hyperpigment Prevention

**Scar
Prevention**

PDT
Photodynamic Therapy





The Appliance of LED

1. Wound Healing



Control

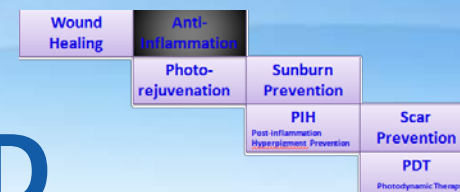


After CO2 ablative resurfacing



After LED
Treatment 48 hours

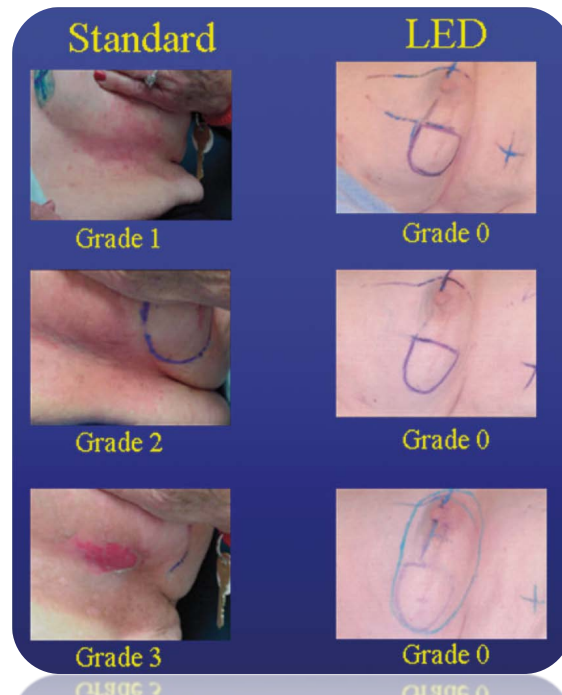
Applications	Wavelength (nm)	No. of Treatments	Irradiance (mW/cm ²)	Fluence (J/cm ²)	Treatment Time (min;sec)	Interval Treatment Time (hours)	Mode (Pulsed/CW)
Wound healing	660 & 850 combination	3-12	50 (minimal)	4	2:40	24-72	Sequential pulsing**



The Appliance of LED

2. Anti-Inflammation

Typical skin reactions post-RT compared with typical reaction post-RT+LED.



Treatment of Radiation-Induced Dermatitis With Light-Emitting Diode (LED) Photo-modulation.

JAAPA 2005, 11:54–62.

Grade			
0	1	2	3
None	Faint erythema or dry desquamation	Moderate to brisk erythema or patchy moist desquamation, mostly confined to skin folds and creases; moderate edema	Confluent moist desquamation, ≥ 10 cm diameter, not confined to skin folds; pitting edema

Applications	Wavelength (nm)	No. of Treatments	Irradiance (mW/cm ²)	Fluence (J/cm ²)	Treatment Time (min;sec)	Interval Treatment Time (hours)	Mode (Pulsed/CW)
Inflammation/erythema/edema	630-660	3-12	50 (minimal)	4	2:40	48-72	Sequential pulsing



Wound Healing	Anti- Inflammation		
	Photo- rejuvenation	Sunburn Prevention	Scar Prevention
		PIH Post-Inflammation Hyperpigment Prevention	PDT Photodynamic Therapy

The Appliance of LED

3. Photorejuvenation



Applications	Wavelength (nm)	No. of Treatments	Irradiance (mW/cm ²)	Fluence (J/cm ²)	Treatment Time (min;sec)	Interval Treatment Time (hours)	Mode (Pulsed/CW)
Photorejuvenation	630-660	12	50-100	4	2:40-16	48-72	Sequential pulsing

The Appliance of LED

4. Sunburn Prevention

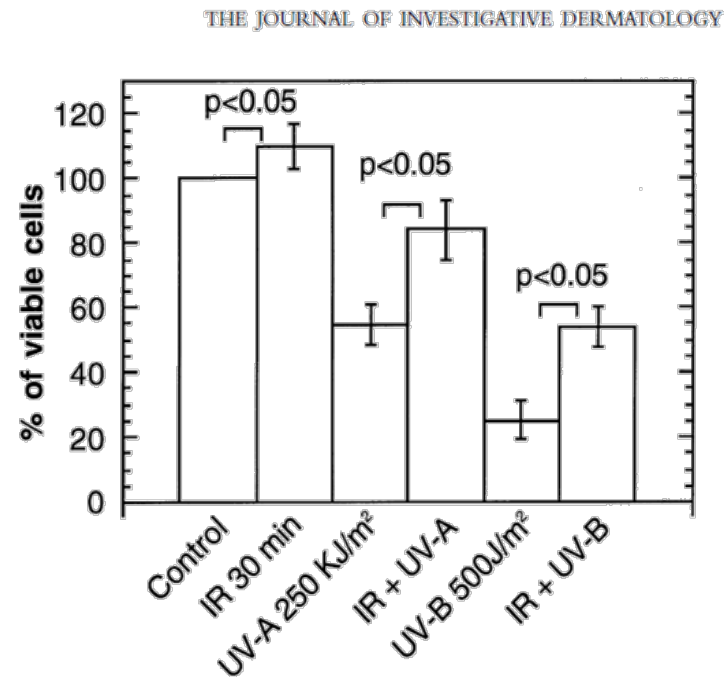
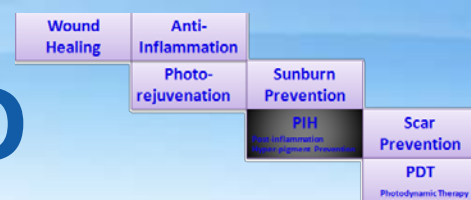


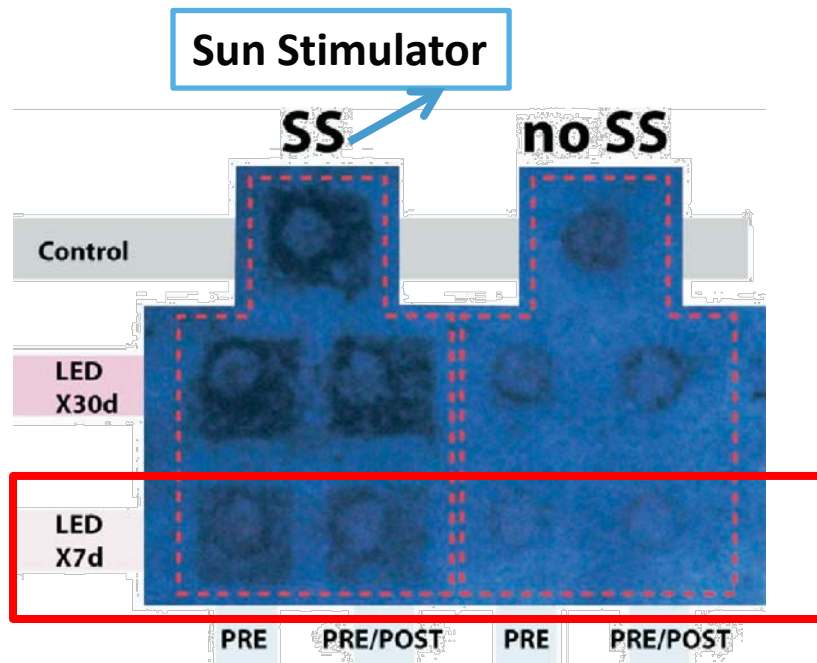
Figure 1. Pre-irradiation with near-IR protects human skin fibroblasts from solar UV cytotoxicity. The cells were exposed (or not) to 30 min of IR radiation (810 kJ per m²), washed two times with HBSS, and irradiated immediately with UVA or UVB. After UV irradiations, the cells were washed again with HBSS and incubated in culture conditions with their original medium for 24 h (UVA) or 72 h (UVB), before counting viable cells. The columns represent the mean $\pm$ SD of three independent experiments in triplicate. Student's paired t test p values < 0.05 are statistically significant.

Applications	Wavelength (nm)	No. of Treatments	Irradiance (mW/cm ²)	Fluence (J/cm ²)	Treatment Time (min;sec)	Interval Treatment Time (hours)	Mode (Pulsed/CW)
Sunburn prevention*†	660-970	ad 7	50	4	2:40-15	24-48	Sequential pulsing or CW

The Appliance of LED



5. Post-inflammation Hyperpigment Prevention (PIH)



The 7-day LED treatment before UV insult appears to be the best regimen to prevent PIH.



Applications	Wavelength (nm)	No. of Treatments	Irradiance (mW/cm ²)	Fluence (J/cm ²)	Treatment Time (min;sec)	Interval Treatment Time (hours)	Mode (Pulsed/CW)
PIH prevention*†	870-970	ad 8	50-80	45-96	15-20	24-48	Sequential pulsing or CW



The Appliance of LED

Wound
Healing

Anti-
Inflammation

Photo-
rejuvenation

Sunburn
Prevention

PIH
Post-inflammatory
Hyperpigmentation Prevention

Scar
Prevention

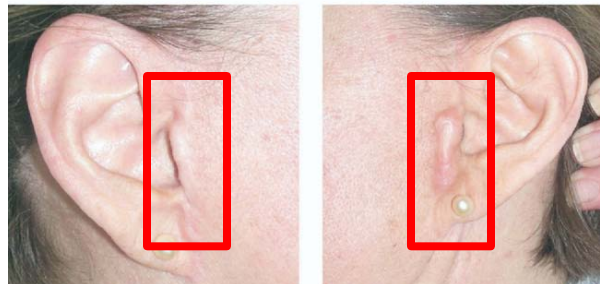
PDT
Photodynamic Therapy

6. Scar Prevention

After Facelift



Facelift
12 month After



LED Treated No Treated
30days

Applications	Wavelength (nm)	No. of Treatments	Irradiance (mW/cm ²)	Fluence (J/cm ²)	Treatment Time (min;sec)	Interval Treatment Time (hours)	Mode (Pulsed/CW)
Scar prevention*	805-970	Multiple	50-80	45-72	15	24	CW

The Appliance of LED

Wound Healing	Anti-Inflammation	Sunburn Prevention	Scar Prevention
	Photo-rejuvenation	PIH Post Inflammation Hyperpigment Prevention	PDT Photodynamic Therapy

7. Photodynamic Therapy(PDT)



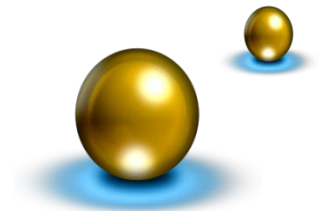
Device Parameters	Blu-U	Omnilyx Revive
Wavelength (nm)	417nm	633nm
Power Density (mW/cm ²)	10	105
Working Distance Gauge	No	No
Treatment time (sec)	1000	1200-1800

Applications	Wavelength (nm)	No. of Treatments	Irradiance (mW/cm ²)	Fluence (J/cm ²)	Treatment Time (min;sec)	Interval Treatment Time (hours)	Mode (Pulsed/CW)
PDT	405-630	3+	50-100	>50	13-45	3 weeks	CW or pulsed



The Advantages of LED

- Why do we use LED for therapy?
 1. Low-Level Light (Much gentler)
 2. Do not damage tissue and eyes
 3. Safer
 4. None-toxic
 5. None-Invasive





Is there another appliance of LED?
Why did author just use LED in dermatology?



*It may be the fast and the easiest method
to reflect the advantages of LED.*

Reference 1

LED in Tissue Regeneration

Title	Disease	Color Wavelength	Energy (J/cm ²)	Model	Reference
The effects of low-level light emitting diode on the repair process of Achilles tendon therapy in rats.	tenotomy →tissue repairing	Red 640±20 nm	20 J/cm ² (120 s)	Thirty albino male Wistar rats	Lasers Surg Med. 2010 Aug
Effect of light-emitting diode (LED) therapy on the development of osteoarthritis (OA) in a rabbit model.	Osteoarthritis	high intensity red 630 nm and IR870 nm	~2 J/cm ² (red) and 2.5 J/cm ² (IR)	14 female New Zealand White rabbits	Biomed Pharmacother. 2011 Jun
Effect of near-infrared light-emitting diodes on nerve regeneration.	injured optic nerve	NIR LED 660nm	1hr total energy 27(J/cm ²)	rat	J Orthop Sci. 2010 Mar

Reference 2

LED in Tumor Therapy

Title	Disease	Color Wavelength	Energy (J/cm ²)	Model	Reference
Photodynamic Therapy-Induced Apoptosis of HeLa Cells.	kills cancer cells	Green 530 ± 15 nm	1.6 J/cm ²	HeLa Cells	Ann N Y Acad Sci. 2009 Aug;1171:6 17-26.
Indocyanine green-based photodynamic therapy with 785nm light emitting diode for oral squamous cancer cells.	Kills oral squamous cancer cells	Green 785nm	50mW/cm ² at 0.5A	oral squamous cancer cells	Photodiagnosis Photodyn Ther. 2011 Dec;8(4):33 7-42. Epub 2011 Jul 12.

Reference 3

LED in MSC Proliferation

Title	Disease	Color Wavelength	Energy (J/cm ²)	Model	Reference
Increased mobility and stem-cell proliferation rate in <i>Dugesia tigrina</i> induced by 880 nm light emitting diode.	Increased mobility and stem-cell proliferation rate	NIR radiation 880 nm	~0.01 J/cm ²	Planarian <i>Dugesia tigrina</i>	J Photochem Photobiol B. 2011 Feb7
The effect of noncoherent red light irradiation on proliferation and osteogenic differentiation of bone marrow mesenchymal stem cells	proliferation and osteogenic differentiation of bone marrow mesenchymal stem cells	red light 620 nm	0, <u>1</u> , 2 and 4 J/cm ²	bone marrow MSCs	Lasers Med Sci. 2012 May
Effects of Red Light-emitting Diode Irradiation on Dental Pulp Cells	Dental repair	red light 653nm	0.149 J/cm ² 0.224 J/cm ²	dental pulp cells	J Dent Res. 2012 Aug 9.

Why can't LED be used widely ?

1. Penetrating

LED can't reach deeper position.

2. Light Disperse a greater surface area.

It can not just focus on a point.

*The technique of LED still need
to be improved .*

LEDs in dermatology can treat a variety of cutaneous problems as a stand-alone application or complementary treatment modality or as one of the best photodynamic therapy light source.