2µm MEDICAL LASER APPLICATIONS

HIGH PRECISION, MINIMAL THERMAL INJURY ZONE

Over the past few decades, lasers have become an increasingly crucial part of a multitude of different technologies, including medical applications. Finely-focused surgical lasers can cut through human tissue easily, neatly, and from a variety of angles, thereby replacing conventional tools such as scalpels. While lasers with an output wavelength of 1–1.5µm are readily available and commonly used, significant developments have been made for 2µm lasers that make them as efficient, stable, and easy to use, while offering significant advantages for medical and surgical applications.

Absorption in Water

2µm lasers are ideal for highly precise surgery due to the high absorption of 2µm radiation in water molecules, which comprise the majority of human tissue. The strong absorption occurs because of the stretching and bending vibrations of the O-H bonds in water molecules and the vibrational frequency corresponding to 2µm radiation. It is hard to accurately quantify the absorption due to the different vibration modes that O-H bonds can have but the increase in absorption can clearly be seen. Figure 1 shows the absorption spectrum for water as well as the tissue penetration depth for a variety of common laser types. It shows a high absorption peak and an optimally small and precise penetration depth at 2µm, as opposed to the peak at 3µm which does not offer enough penetration depth for surgical applications.

Figure 1

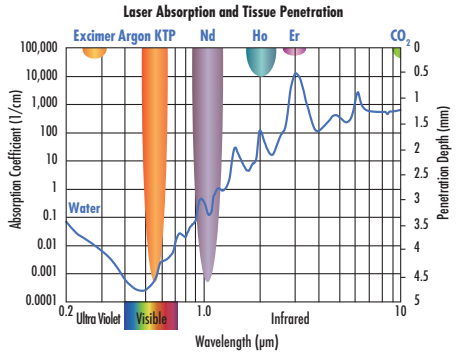

Figure 1: Absorption of water and tissue penetration depth at different wavelengths

Due to this high absorption, ablation, or the removal of tissue, can be achieved using 2µm lasers with a very small injury zone of about 0.5mm. In addition, coagulation, or the process by which blood changes from a liquid to semi-solid state and forms a blood clot, occurs when exposed to 2µm radiation. This suppresses the bleeding during a surgical procedure making the process cleaner, easier, and more efficient. Coagulation that is too deep, however, can cause complications post-procedure. 2µm lasers offer a low and ideal coagulation depth of about 0.1-0.2mm which allows for the optimal "bloodless" effect as well as confined thermal injury, as shown in Figure 2.

Figure 2

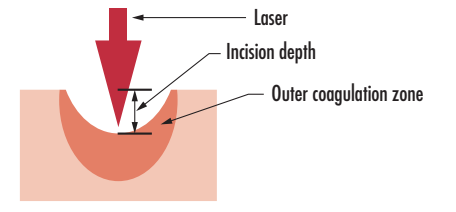

Figure 2: Depth of Coagulation

In addition, due to the high absorption levels of 2µm radiation in water, the speed of cutting and vaporization remains relatively constant regardless of how vascular the tissue is. The high efficiency, consistency, and good thermal management of these lasers makes them ideal for surgical applications.

As a comparison, radiation from more common 1µm lasers have much lower absorption and penetrate deeper into the tissue than 2µm lasers. This results in larger areas of injury and more unnecessary dead tissue. Because surgery is a very precise process, the depth of cuts need to be finely controlled in order to reduce damage to the underlying tissue. 2µm lasers offer this precision and should be considered for these surgical applications.

2µm MEDICAL LASER APPLICATIONS	
Neurosurgery Fenestration of cysts Ventriculocisternosomy 3rd ventriculostomy Tumor resection Haemostasis	**Ear Nose & Throat (ENT)** Tonsillectomy Stapedectomy Excision of tumors Excision of granulomas UVPP
Pneumology Bronchoscopy Airway recanalization De-obstruction Tissue coagulation	**Spinal Surgery** Laser discectomy Laser foraminoplasty PLDD
Gynecology Excision of polyps Endometriosis Hysterectomy Adhesiolysis Conisation Myomectomy	**Urology** Vaporesection of prostate Vaporization of prostate Resection of prostate Enucleation of prostate Bladder neck incision Opening of strictures Vaporization and excision of bladder tumors Partial nephrectomy Laparoscopy Lithotripsy
Athroscopy Capsular shrinkage Cartilage smoothing Meniscectomy Synovectomy	**General Surgery** Surgery of well circulated organs Tissue vaporization Volume coagulation Hemorrhoids

Table 1: List of different surgery applications that can be carried out with laser systems operating in the 2µm wavelength range. Applications marked in red use pulsed laser systems.

Conclusion

Laser technology around the 2µm spectral region has proven very useful in medicine and surgery. Due to the high absorption in biological tissue, small thermal injury zone, consistency, practical output powers, and readily available optical materials for these lasers, they will continue to increase in popularity and become an effective solution for laser surgery in the years to come.

References

"Chapter 5 Medical Uses of Lasers." Science Clarified. N.p., n.d. Web.
"Fiber Lasers Find Opportunities in Medical Applications." Pardon Our Interruption. N.p., n.d. Web.
"Lasers in Medicine." SPIE Professional: Lasers in Medicine. N.p., n.d. Web.
"Minimally Traumatic and Inexpensive Ceramic Laser Scalpel." ScienceDaily. ScienceDaily, n.d. Web.
Scholle, Karsten, Samir Lamrini, Philipp Koopmann, and Peter Fuhrberg. "2 µm Laser Sources and Their Possible Applications." Frontiers in Guided Wave Optics and Optoelectronics (2010): n. pag. Web.
"Understanding Processing with Thulium Fiber Lasers." Industrial Laser Solutions. N.p., n.d. Web.

USA: +1-856-547-3488 | EUROPE: +44 (0) 1904 788600
ASIA: +65 6273 6644 | JAPAN: +81-3-3944-6210