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By Dr. Sagar A. Jawale

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Low Cost ND: YAG Medical Laser as a Lithotripter and Laser Cautery Machine

Dr. Sagar A. Jawale

I. Introduction

Lasers have extensive application in medical sciences today but unfortunately the cost of medical Lasers is exorbitant and it is beyond the capacity of an average doctor to afford it. To solve this problem, I did my own research and developed low cost medical Laser which most of the doctors can afford.

II. Aims and Objectives

To develop a cost-effective medical laser for vast majority of medical applications such as lithotripsy, photocoagulation, cauterization, Laser tissue welding etc.

III. Technology

20-watt 950 nm ND: YA Gdiode laser machine: (Photo 2,4) It was made by coupling a 0.1 mm optical fiber (Photo 1) to a 20- watt 950 nm ND YAG diode laser(Photo 3). Photo 4 shows the interior of the machine showing Laser diode with cooling fan and power supply and exhaust fan. The machine has a foot switch to precisely control the on and off function. It has a power control nob which controls power from 0-20 Watts. The fiber is detachable from the main machine. It can be detached and sterilized by putting in Formalin chamber or by Ethylene Oxide gas. Patent is applied at Mumbai office for this invention.

A Laser Diode (Photo 3) is a semiconductor device similar to a light-emitting diode (LED). It uses p-n junction to emit coherent light in which all the waves are at the same frequency and phase. This coherent light is produced by the laser diode using a process termed as "Light Amplification by Stimulated Emission of Radiation", which is abbreviated as LASER. And since a p-n junction is used to produce laser light, this device is named as a laser diode.

Neodymium-doped yttrium aluminum garnet (Nd: YAG) is a crystal that is commonly used as a lasing medium for solid-state lasers. J. E. Geusic et al first explained the laser operation of Nd: YAG at Bell Laboratories in 1964. Nd: YAG is formed by replacing a small quantity of yttrium ions in the YAG crystal structure with triply ionized neodymium that serves as a dopant. The ions are replaced due to the fact that they are of same size. The neodymium ion acts as the lasing medium in the Nd: YAG crystal.

Nd: YAG laser consists of a four-level gain medium that offers extraordinary laser gain at moderate pump intensities and excitation levels. The gain bandwidth of the laser is relatively small, which in turn improves laser's gain efficiency thereby minimizing threshold pump power. It emits infrared light in the range of 1064 nm. It can be lamp pumped or diode pumped. Lamp pumping can be achieved because of the four-level characteristics and broadband pump absorption of the laser in the 800 nm band region.

Specifications of laser diode used in this machine are: Output power:20 Watts, continuous type, Waverlength 950 nm,spectral width 6 nm,threshold current 600 mA,Operating current 11 Amp,Operating voltage 5.7 Volt,Operating temperature 25 degree centigrade, life 50,000 hour.

Specifications of the fiber used are:Type-single mode, Core diameter 100 micrometer,numeric aperture 0.15, cladding diameter 125 micrometer,buffer diameter 250 micrometer, total outer diameter of jacket 1 mm.

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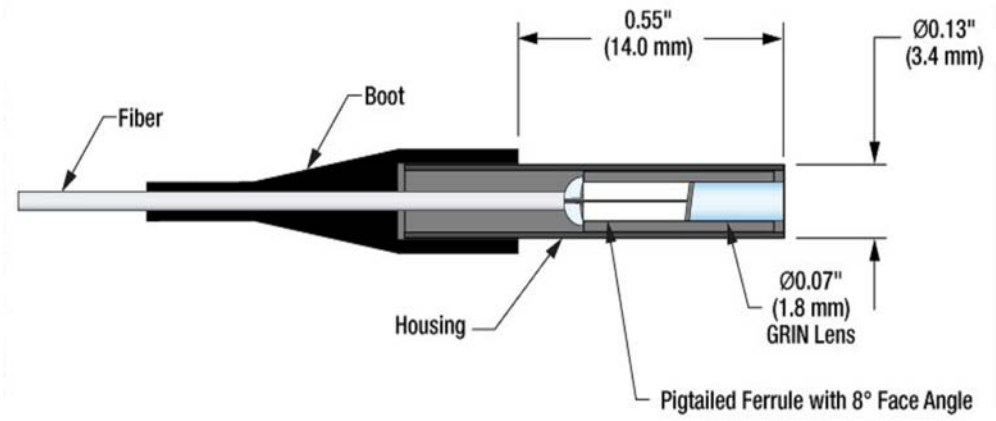


Photo 1: Fiber coupled with GRIN lens in pigtailed ferrule

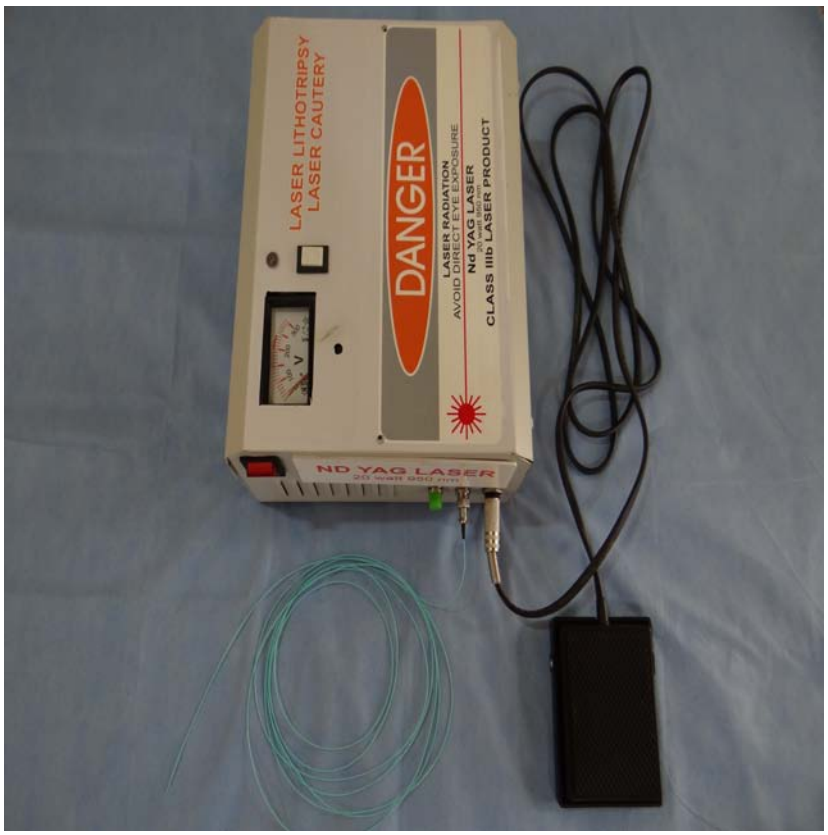


Photo 2: 20 Watt Nd: YAG Laser machine

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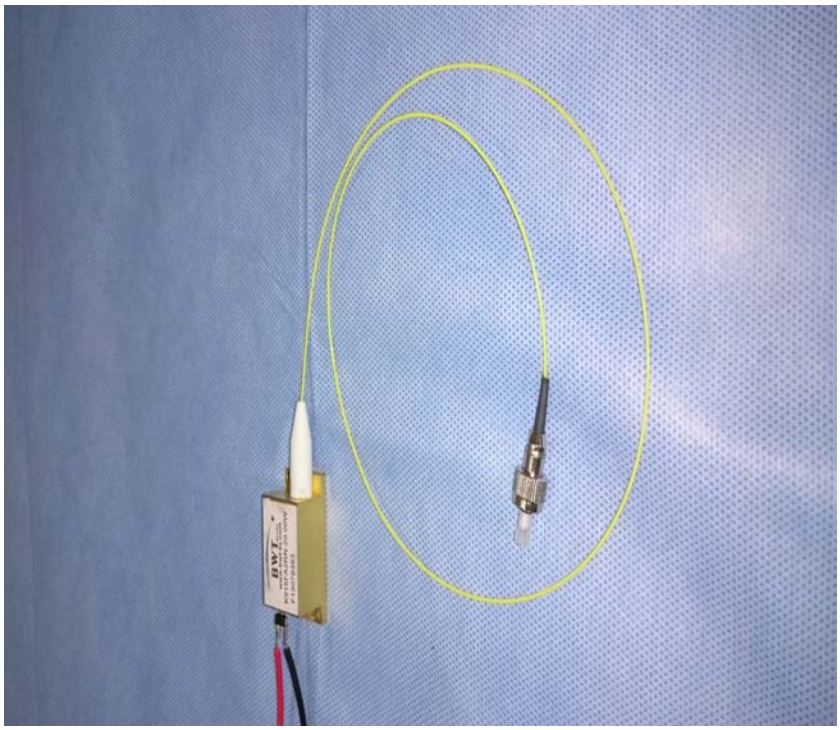


Photo 3: Laser diode coupled with 0.1 mm optical fiber



Photo 4: Showing inner view of the machine-Laser diode with cooling fan and power supply

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Photo 5: Kidney stone broken partially by Nd: YAG Laser

IV. Discussion

Medical lasers cost in the range of USD 50,000-75,000. It is beyond the capacity to afford particularly in third world countries like India. The machine [Photo1,3] is made in just USD 500 vs market cost of USD 50,000. It is commercialized at a reasonable cost of USD 1000. That makes it the cheapest medical laser in the market in that category. Such an invention is unique and reported for the first time in medical literature. A patent is registered for this innovation at Mumbai office.

ND: YAG Laser has vast applications in medical sciences for the treatment of tumors [4] Nd: YAG lasers emitting light at 1064 nm have been the most widely used laser for laser-induced thermotherapy, in which benign or malignant lesions in various organs are ablated by the beam. Other applications are hereditary hemorrhagic telangiectasi a [5], head and neck hemangiomas [6], in surgical gastroenterology [7], for tracheobronchial lesions [8,9] etc. Nd: YAG lasers are used in ophthalmology to correct posterior capsular opacification, a condition that may occur after cataract surgery, and for peripheral iridotomy in patients with acute angle-closure glaucoma, where it has superseded surgical iridectomy. Frequency-doubled Nd: YAG lasers (wavelength 532 nm) are used for pan-retinal photocoagulation in patients with diabetic retinopathy. In certain cases these lasers are also used to treat eye floaters. [10].

In oncology, Nd: YAG lasers can be used to remove skin cancers.[11] They are also used to reduce benign thyroid nodules,[12] and to destroy primary and secondary malignant liver lesions.[13] [14]To treat benign prostatic hyperplasia (BPH), Nd: YAG lasers can be used for laser prostate surgery—a form of transurethral resection of the prostate. These lasers are also used extensively in the field of cosmetic medicine for laser hair removal and the treatment of minor vascular defects such as spider veins on the face and legs. Nd: YAG lasers are also used to treat Venous Lake lip lesions.[15] Recently used for Dissecting cellulitis of the scalp, a rare skin disease.[16] Using hysteroscopy the Nd: YAG laser has been used for removal of uterine septa within the inside of the uterus.

In Dentistry, Nd: YAG dental lasers are used for soft tissue surgeries in the oral cavity, such as gingivectomy, periodontal sulcular debridement, LANAP, pulpotomy, frenectomy, biopsy, and coagulation of graft donor sites.

The same 20- watt 950 nm ND: YAG diode laser machine can be used as a cautery machine by adding a laser guide (Photo 5) to the optical fiber. It can be used as an end ocautery in laparoscopy [Photo 6] by adding a long laser guide. The Laser cautery is far more versatile and superior to the conventional electro cautery. Carbon does not form at the tip of the fiber which needs to be cleaned periodically as in electro cautery. Laser cautery is far more precise and damage to surrounding tissues is negligible as compared to electro cautery. The lasers have great photo coagulating properties. Bleeding that does not stop with electro cautery stops with laser cautery. The use of lasers in laparoscopy is quite new.

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Photo 6: Laser guide for open surgery

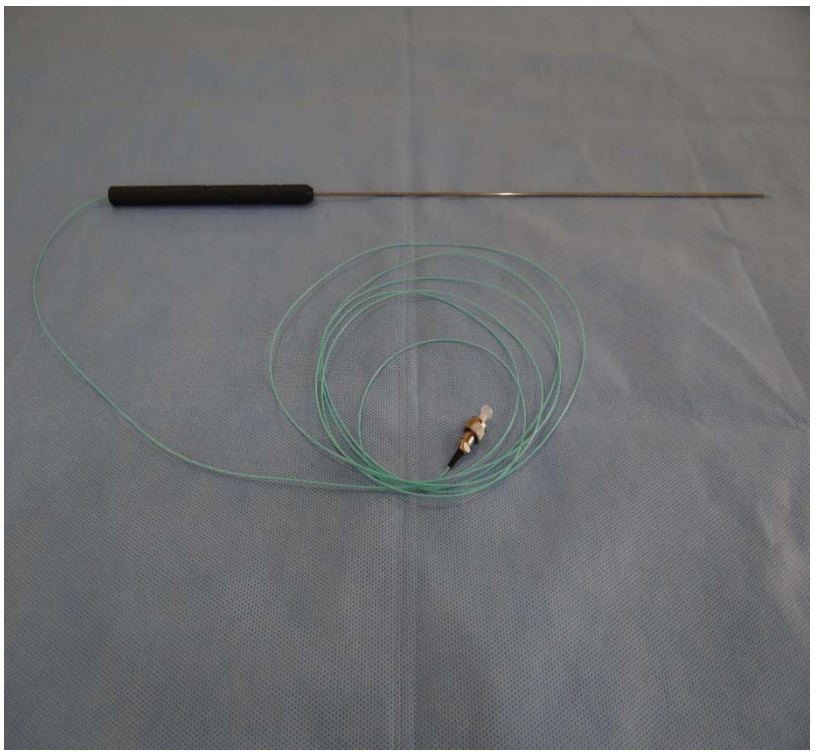


Photo 7: Laser guide for laparoscopic surgery

The 1 mm optical fiber jacket can pass through working channel of rigid as well as flexible endoscopes. The author has used the machine for breaking bladder, ureteric and kidney stones (Photo 5) and for photocoagulation of facial hemangiomas. The laser was found to be more effective as lithotripter particularly for gall stone which are softer that renal stones.

The author has also used the machine for following applications. Laser tissue welding (Photo 8) is a novel technique where 40 % human albumin is put into

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a wound and 5 -Watt Infrared laser of 950 nm is applied over it. At 60-degree centigrade temperature it leads to a formation of a watertight bond of proteins over the tissues by the photo polymerization effect of laser and gives about two weeks of healing in just two minutes. A costly USD 10,000 machine is used for the purpose which is also not commercially available. My laser machine kept at 5-watt power achieved the same result. Tissues such as spleen, liver, pancreas, brain and kidneys where sutures do not hold well are indications for this technique.



Photo 8: Circumcision done with Gluteraldehyde albumin dye induced laser tissue welding

Gluteraldehyde Albumin glue Induced Laser Tissue Welding (2), (Photo 8): 0.9 ml 40 % human albumin is taken in 1 ml syringe and mixed with 0.1 ml of 10 % glutaraldehyde solution. The syringe is shaken vigorously to mix both the components. My Laser machine is set at 5 watts power and illuminated over this bond for 60 seconds to polymerize it. It forms a watertight strong bond over the tissues. The technique has vast applications in surgery such as for sealing post-operative wounds, CLW closure, reinforcement of suture line of bowel an astomos is, Bowel perforation, sealing dura repair, hypospadias surgery, urological operations etc.

Frenotomy Operation by Methylene blue Dye enhanced Laser Tissue Cutting (3), (Photo 8) This new technique is reported for the first time in the medical literature. Cheap infra-red Lasers do not act on tissues which are of the same color and in fact reflected. To solve this problem, I infiltrated tissues with opposite color Methylene blue which is already FDA approved for use in human body. My Infrared laser now acted only on blue infiltrated areas and saving surrounding tissues of any co lateral damage. Because of the Methylene blue dye, my cheap infrared laser can be used for this purpose. Otherwise, a high frequency 2000 nm and high wattage (40 Watt) laser has to be used which is extremely costly (USD 50,000) and is not affordable to most surgeons. The only disadvantage of laser against electrocautery was cost which is eliminated in this technique. The technique also becomes a foundation as a learning experience for its wider application in other areas of surgery such as Photocoagulation in liver surgery, renal surgery, brain surgery, on pancreas etc.

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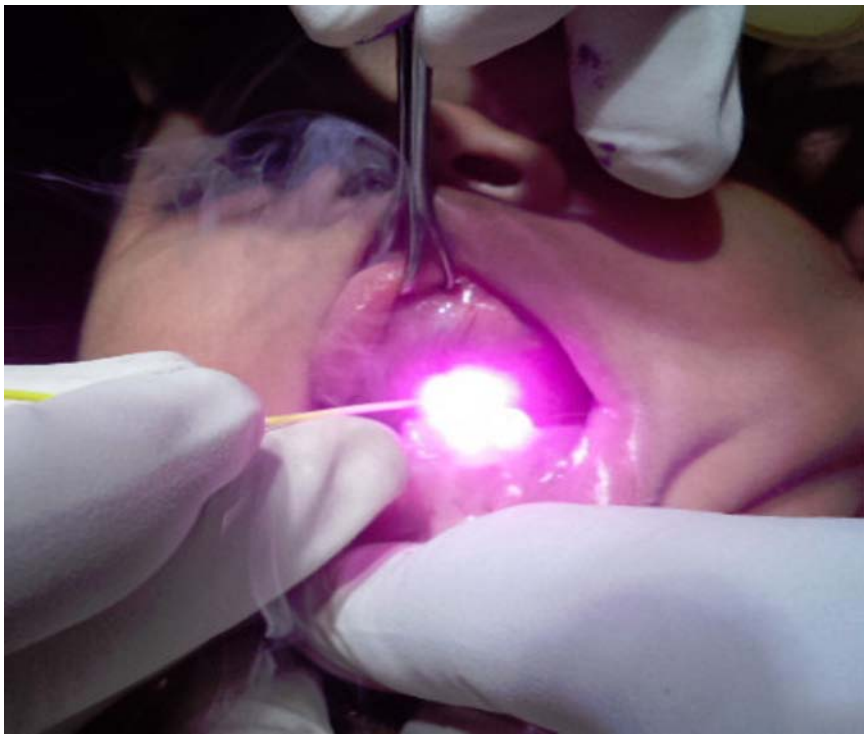


Photo 8: Frenotomy operation done by methylene blue dye enhanced laser tissue cutting

V. Conclusion

I successfully developed the cheapest ND: YAG medical laser in the world which can act as a lithotripter for gall stones and kidney stones. It can also act as a laser cautery in open and laparoscopic surgery. The machine has a potential to make a variety of laser surgeries affordable to a vast number of patients worldwide.

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