

MASER TO LASERS: A REVIEW

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ABSTRACT:

Laser – ‘Light Amplification By Stimulated Emission Of Radiation’, Albert Einstein postulated its theoretical basis. Laser is a unique equipment in armamentarium of modern dentistry. It has evolved from ‘Pre Maser’ to ‘Maser’ and now finally to ‘Lasers.’ The evolution period is classified as Pre Masers (1916 to 1953) when the existence of stimulated emission process was discovered and led to a radiation amplifier, then Maser period (1954 to 1960) when several Maser types came into existence and finally in 1960, Ruby lasers invented by Theodore H. Maiman, led to discovery of various types of lasers leading to excellent clinical success. This article throws Beam of Light on eventful journey of Masers to Lasers.

Key words: Masers, Lasers.



INTRODUCTION:

Laser light production's theoretical basis was introduced some 90 years ago. Laser is a proposal made by Albert Einstein in 1916 that under proper conditions, atoms are able to release excess energy as light – either voluntarily or when stimulated by light. The time has probably come when it is worthwhile to look back over past years and review the early history of Laser. The History of invention or the evolution of laser may be classified into Pre Maser, Maser and the Laser Period. This article is

primarily concerned with the first periods and with the early phases of Laser period which seems to extend into the present.^[1,3]

The Pre maser Period: It started with discovery of existence of stimulated emission process and ended with possibility that this process might lead to a radiation amplifier. Max Planck's published work in 1900 provided the concept stating that Light is a form of electromagnetic radiation. In absence of this concept, laser would not have been developed. In 1917, principle of the laser was first known when Albert

Einstein gave the theory of stimulated emission which later was known as Light Amplification by Stimulated Emission of Radiation (LASER) an acronym coined by Gordon Gould(1957). Fabrikant predicted the practical importance of a light amplifier which can be modulated and he identified the effectiveness of enclosing the amplifying material in a resonant structure. His work is historically interesting because he endeavoured to develop the Laser without passing through the maser phase as his American Colleagues did.^[3,14]

The Maser Period: An intense outburst of research on maser followed in the mid-1950s, but only limited range of applications of masers was found, such as minimal-noise microwave amplifiers and atomic clocks. The electromagnetic spectrum is comparative arrangement of electromagnetic energy (photonic quanta) related to wavelength, extending ultra-short gamma and X-radiation, through the visible light, to the ultra-long micro- and radio-waves. Charles Townes, experimented with microwaves and developed a device by which these radiations could be amplified by passing across ammonia gas. This was the first MASER (microwave amplification by stimulated emission of radiation) and was introduced as a subvention to the communicating systems and time-maintaining (the 'atomic clock'). It was recognized that maser energy could be obtained by converting only a fraction of the incident energy, the emission greatly dispositioning heat; the accomplished power of the early masers was in sequence of a few micro-watts.^[2,3]

In 1951, Dr. Townes gave the concept of Maser, after few months, Townes and his associates started working on a device utilizing the ammonia gas as an active medium. In early 1954, the first amplification and electromagnetic waves generation by stimulated emission were acquired. Dr. Townes with his students, coined the word "MASER" for this device, the acronym as microwave amplification by stimulated emission of radiation^[12]. In 1958, Dr. Townes, along with his brother-in-law, Dr. A.L. Schawlow (Professor, Stanford University), exhibited theoretically that masers can be made to employ in the optical and infrared region and recommended the way in which it could be efficient in particular systems.

In 1958 Arthur L Schawlow, Charles H Townes : First detailed paper describing "Optical MASER". Credited with invention of LASER from Columbia University.^[2,3,14]

Laser Period: Theodore Maiman Invented first working LASER based on Ruby. During 1961, Laser Research & development expanded rapidly. Although search for new laser materials continued. As the laser field expanded, considerable effort was directed towards obtaining technical improvements in existing lasers. The most auspicious success in this endeavor was the invention of Giant-pulse Laser by Hell-Warth and McClung. One of the first laser applications was that of optical ranging. Ranging experiments began at the Hughes Research Laboratories in 1960 and operable range finders were constructed during late 1961.^[3]

DISCUSSION:

'Laser' – is a synonym for 'light amplification by stimulated emission of radiation. Albert Einstein hypothesized its theoretical basis^[1]. In 1960, tooth was first subjected to laser light. During the 1960s, first laser was revealed into the fields of medicine and dentistry (Goldman *et al.*, 1964)^[8]. The laser beam decomposes or breaks molecular bonds within the target tissue without producing heat, limiting thermal damage to surrounding tissues. Basically, laser is a beam generated when an external power source stimulates a chamber of a laser medium – solid, liquid or gas. The resulting spontaneous emission of photons resonates between the mirrored ends of the laser chamber. These bouncing photons further excite other atoms in the laser medium. Momentum builds until a highly concentrated beam of light passes through the partially transmitted mirror at one end of the chamber.

Laser light is monochromatic, coherent and collimated. Lasers are usually named for the "active medium" impregnated with energy inside the laser, unit for creating laser light. When laser energy strikes tissue, it may be absorbed by it, transmitted through it, scattered within it or reflected. Absorbed laser energy vaporizes and carbonizes tissue most effectively. Laser can be adjusted to vary the power and the size of the focal point, enabling the laser beam to cut, vaporize or coagulate the tissue. The beam may be impulsed, incrementally activated for a microsecond or activated on a continuous beam. ^[4,11]

The first laser was evolved by Theodore H. Maiman. Using a theory originally postulated by Einstein, Maiman created a device where a crystal medium was stimulated by energy, and radiant, laser light was emitted from the crystal. This first laser was a Ruby laser. One year later, Snitzer released the neodymium laser (Nd:YAG). The search for a laser system with broader applications in dentistry led Dr. Terry Meyers and his brother William, an ophthalmologist, to select the Nd:YAG laser for experiments on the removal of incipient caries (Meyers, Meyers, 1985).^[6]

First experimentation on lasers in dentistry was delineated in a study which summarized the effectiveness of a pulsed ruby laser on humans in tooth caries (Goldman *et al.*, 1964)^[8,9]. Results of that study exhibited that the effects varied from holes of 2-mm depth to till the complete vanish of the carious tissue, with little whitening of the neighbouring enamel rim, specifying the extensive demolition of carious areas along with formation of crater and melting of dentine.^[8,9]

Er: YAG laser was evaluated for its capacity of vaporizing the dental hard tissues (Gimbel, 2000). The Er: YAG laser was used for favourable preparation of the enamel and dentin cavities.^[7] Since then, this laser has been used for caries removal and preparation of cavity, minor surgery of soft tissue and scaling (Aoki and Watanabe *et al.*, 1998).^[13]

TYPES OF LASER IN DENTISTRY:^[10]

I) Based on the type of laser medium used:

a) Gas laser	solid laser	Liquid laser	Electronic laser
-Helium Cadmium	Ruby	Liquid dye	Semiconductor
-Helium neon	Rhodamine	Water vapour	Diode
-Argon	Neodymium		
-Nitrogen	Erbium		
-Carbon dioxide			
-Krypton			
-Carbon monoxide			

II) Based on the type of delivery system:

	Gallium arsenide
Flexible hollow wave guide/articulating arms	Gallium aluminium arsenide
Glass fiber optic cable	b) Hard tissue laser-high power about 3 w or more

III) Based on laser modes:

Continuous mode	Argon laser
Gated mode	CO2 laser
Pulsed mode	Nd;YAG laser
	Er;YAG laser

IV) Based on type of interaction with tissue:

Contact laser	Er;YSGG ^{10]}
Noncontact laser	

V) Based on type of application:

a) Soft tissue lasers-low power about 1 w

The 3 main types of lasers are-

Helium Neon

Gallium neon

Some of the important types of lasers are Carbondioxide Lasers, Neodymium:Yttrium-Aluminium-Garnet Lasers and Argon lasers.

Carbon Dioxide (CO₂) laser has been used successfully in soft-tissue surgeries such as gingivectomies, frenectomies and for endodontic purposes.

Neodymium:Yttrium-Aluminium-Garnet (ND:YAG) lasers have been used to sterilize tooth surface, treatment of hypersensitivity, bleaching and pit and fissure sealants.

Argon Lasers are used to polymerize dental resins.^[5]

In Dentistry, Lasers are used for:^[6,10]

i) As Diagnostic aid for vitality of Pulp, Doppler flowmetry, Low level laser therapy (LLLT), Laser fluorescence- Caries detection, bacteria and dysplastic changes (for diagnosing cancer).

ii) Caries removal, cavity preparation & bone recontouring, crown lengthening

iii) In Endodontics for root canal preparation, sterilization, Apicectomy, Pulp capping procedures, Pulpotomy and pulpectomy

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iv) Lasers are used for tissue curettage and peri-apical surgery, Gingivectomy and Gingivoplasty, Frenectomy and Gingival retraction, Granulation tissue removal, Pulp capping procedures, Pulpotomy and pulpectomy

v) Laser activation for Restorations (composite resin), Bleaching agents

vi) Other indications of lasers are:

- Laser-induced analgesia

- For removing root canal filling material & broken instrument, Removal of moisture/drying of canal softening of gutta percha.^[6,10]

CONCLUSION:

Lasers do have far – reaching potential for application in dentistry. Laser procedures give you a highly eminent, state-of-the-art dentistry because of new treatment modalities and intensification to standard treatments, with reduced need of anaesthesia during treatment and a great reduction in post-treatment pain. Despite the laser's ability to perform many procedures without anaesthesia, the instrument is not a magic wand.

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