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Laserska vrhunska tehnologija z vidika proizvajalca

Laser High Technology: a Manufacturer's Viewpoint

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Za lasersko vrhunsko tehnološko industrijo velja paradoks neprofitne blaginje. Na eni strani laserska industrija kaže izredno neenakomerno spreminjanje prihodka in stroškov ter skromen izkupiček delničarskih investicij. Na drugi strani pa je laserska tehnologija priljubljena in se hitro razvija. V tem članku je opisanih nekaj osnovnih značilnosti laserske industrije. Prvič, laserska tehnologija je bolj priljubljena pri proizvajalcih kakor pri uporabnikih. Drugič, različna področja uporabe laserske tehnologije zahtevajo različen razvoj in marketinški postopek. Tretjič, stroški za razvoj in raziskave so dokaj visoki, pogosto pomenijo nekaj nad 10 odstotkov prihodka od prodaje. V tem članku na primeru zobnega laserja TWINLIGHT prikazujemo, kako se laserska industrija spoprijema z izzivi, ki se pojavljajo pri razvoju nekonvencionalnih tehnologij.

It has been pointed out that the laser high tech industry has been a paradox of profitless prosperity. Namely, the industry has exhibited highly erratic earnings performance and poor return on shareholders investment, in spite of the fact that laser technology is popular and rapidly evolving. This paper addresses some of the problems that plague the laser industry. One of the biggest problems is that the laser technology is more popular with the industry than the users. Second, different areas of the applications of laser technology require very different development and marketing approaches. And third, the research and development expenditures are quite high, often running at above 10% of the sales revenue. In this paper, we show on the example of a dental laser TWINLIGHT how laser industry approaches the challenges involved in the development of non-conventional technologies.

0 UVOD

Poudarili smo, da za lasersko vrhunsko tehnološko industrijo v povprečju velja paradoks neprofitne blaginje [1]. Industrija uspeva, saj se tehnologija razvija, različne uporabe se še naprej povečujejo. Kljub temu prihaja do izjemno neenakomernega spreminjanja prihodka in stroškov in do nizkega izkupička vloženega kapitala. Le najbolj inovativne in prilagodljive družbe lahko dosežejo uspeh v taki vrhunski tehnološki industriji.

V tem članku obravnavamo značilnosti laserske vrhunske tehnološke industrije z vidika proizvajalca FOTONE d.d.. Prve dejavnosti FOTONE segajo v leto 1964, ko je bil ustanovljen raziskovalni laboratorij v okviru podjetja Iskra. Od takrat je podjetje (ki se je do junija 1994 imenovalo Iskra Elektrooptika) doseglo poslovni uspeh s proizvodnjo več ko 10000 laserskih sistemov. Danes je v FOTONI zaposlenih 500 ljudi, od katerih je 100 vključenih v razvoj in raziskave. Podjetje ima približno 25000 m^2 prostorov v Ljubljani, z dobro opremljeno mehansko in optično delavnico ter oddelkom za naparevanje tankih slojev.

0 INTRODUCTION

It has been pointed out that the laser high tech industry has been on average a paradox of profitless prosperity [1]. The industry is prosperous, since the technology continues to evolve and the applications continue to increase. However, the industry has also exhibited highly erratic earnings performance, and a poor return on its shareholders' investment. It is only the most innovative and adaptive companies that can succeed in this high tech industry.

In this paper, the characteristics of the laser high tech industry are discussed from the viewpoint of a manufacturer, FOTONA Ltd. The first activities of FOTONA reach as far back as 1964, when a research and development laboratory was established in the framework of Iskra. Since then, the company (which was until June 1994 called Iskra Elektrooptika) has achieved business success with the production of more than 10,000 laser systems. Today, FOTONA employs almost 500 people, 100 of them actively involved in research and development. The company has approximately 25,000 m^2 of premises in Ljubljana, including well equipped mechanical and optical workshops, and a coating facility.

1 LASERJI PRI ISKANJU PODROČIJ UPORABE

Laserska tehnologija je vabljiva tehnologija, ki je močno v zavesti ljudi in pogosto je porabnik tisti, ki žene laserski razvoj. Žal je priljubljenost laserske tehnologije še bolj izražena na strani proizvajalcev. Laserska podjetja pogosto vodijo laserski navdušenci, ki se bolj opirajo na tehnologijo kakor na trg. Zato podjetja razvijajo različne tipe laserjev, ne da bi razumela, kakšna naj bi bila njihova dejanska uporaba. Pravimo, da so laserji pri iskanju področij uporabe. Zato obstaja preveč nediferenciranih laserskih podjetij v preobleganem trgu. Tako, na primer, obstaja prek 50 podjetij, ki prodajajo zvezne laserje Nd:YAG na ameriškem zdravstvenem trgu, trenutno ocenjeni potencial pa je približno 500 kirurških laserjev Nd:YAG na leto. Po drugi strani so uporabniki nezaupljivi, slabo obveščeni in pogosto razočarani nad lasersko tehnologijo.

2 RAZVIJATI GLOBALNA ALI LOKALNA PODROČJA UPORABE?

Presenetljivo je, da imamo kljub temu, da so laser izumili pred več ko 30 leti, lasersko tehnologijo še vedno za novo tehnologijo. Proizvajalci se torej ne srečujejo samo z običajnim problemom izboljšanja tehnologije, pač pa morajo razvijati uporabe in jih prenesti uporabnikom. Poleg tega so značilnosti uporabe in prenosa močno odvisne od vrste uporabnikov. Uporaba laserjev v zdravstvu na primer terja dolgoročne klinične raziskave in zakonske postopke. Za že odobreno lasersko napravo traja zakonski postopek v Nemčiji kakih 6 mesecev, v ZDA pa 12 mesecev. Za novo uporabo v ZDA zakonski postopek običajno traja več ko 5 let. Prednost trga z medicinskimi laserji je ta, da so zdravstvene težave pacientov po vsem svetu enake. Zato je lahko postopek razvoja uporabe vrhunsko tehnoloških medicinskih laserjev celoten. Po drugi strani pa industrijske uporabe ne terjajo dolgih zakonskih postopkov. Zato pa skoraj vsak potencialni uporabnik zahteva posebno uporabo laserja in je celotni postopek razvoja uporabe zelo težak.

3 VELIKI STROŠKI ZA RAZISKAVE IN RAZVOJ

Druga značilnost laserske vrhunske tehnologije je, da so stroški za raziskave in razvoj običajno dokaj veliki. Podjetja ne vlagajo samo v razvoj nove laserske tehnologije, pač pa čedalje bolj v uporabo te tehnologije. In ker se tehnologija tako hitro razvija, mora podjetje investirati več ko 10 odstotkov svojih prihodkov v raziskave in razvoj. Zato stroške za raziskave v večini razvitih

1 LASERS IN SEARCH OF APPLICATIONS

Laser technology is a glamorous technology. There is a tremendous awareness of this technology, and very often it is consumer demand that drives laser procedures. Unfortunately, the popularity of laser technology is even more pronounced on the side of the manufacturers. Very often, laser companies are run by laser enthusiasts who are technology and not market driven. This leads to companies developing various types of lasers without understanding the actual applications of these lasers. It is said that lasers are in search of applications. For this reason, there are too many undifferentiated laser companies in the crowded market. For example, there are over 50 companies selling Nd:YAG lasers in the US medical market, with an estimated present potential of approximately 500 Nd:YAG surgical lasers per year. On the other hand, users are skeptical, ill informed, and often disillusioned by laser technology.

2 DEVELOPING GLOBAL OR LOCAL APPLICATIONS ?

It is surprising that, even though the laser was invented over 30 years ago, laser technology is still considered a new technology. Manufacturers are thus not confronted only with the usual problem of improving a technology but are required to develop applications, and to transfer the applications to users. Additionally, the characteristics of the applications and of the transfer differ very much depending on the user segment. For example, applications of lasers in medicine require long term pre-clinical and clinical investigations, and regulatory procedures. For a laser device for an already approved application the regulatory procedure takes approximately 6 months in Germany, and 12 months in the USA. For a new application, the US regulatory procedure would typically require more than 5 years. The advantage of the medical laser market is that health problems are basically the same for all patients in the world. For this reason, the approach to the development of high tech medical laser applications can be global. On the other hand, industrial applications do not require such long regulatory procedures. However, almost every potential user requires a special laser application, and the global approach to the development of applications is very difficult.

3 HIGH RESEARCH AND DEVELOPMENT EXPENDITURES

Another characteristic of laser high technology is that research and development expenditures are typically quite high. Companies must invest not only in the development of new laser technology but more and more in applications of this technology. And because the technology is evolving so quickly, a company must invest above

držav deloma pokriva država, tako da financira projekte, ki jih izvajajo na univerzah in raziskovalnih inštitutih. Brez finančne pomoči države laserska industrija ne bi mogla donosno razviti novih področij uporabe laserske tehnologije. Sodelovanje industrije z univerzami in raziskovalnimi inštituti prinaša novo izmero pri tem delu. Zanimanja in cilji raziskovalnih inštitutov se pogosto precej razlikujejo od zanimanj in časovnih okvirov industrije. Zato morajo biti industrijske skupine za raziskave in razvoj izredno izobražene in izkušene v osnovnem raziskovalnem delu, da bi lahko sodelovale z univerznimi raziskovalnimi skupinami in velikokrat tudi prevzele pobudo za raziskovalne projekte.

4 FOTONA: ZDRAVSTVENI IN INDUSTRIJSKI PROGRAM

V FOTONI smo se začeli ukvarjati z industrijsko lasersko tehnologijo, ko smo se v poznih sedemdesetih letih odločili za razvoj in proizvodnjo laserjev CO_2 velike moči, večinoma za rezanje kovin. Do leta 1990 je FOTONIN program vključeval več tipov velikih laserskih sistemov CO_2 (z močjo do 600 W) in laserje Nd:YAG srednje moči (50 W), ki so se prodajali na področju takratne Jugoslavije, Vzhodne Evrope in Kitajske. Razlogi, zakaj so se v FOTONI leta 1991 odločili opustiti svoj program CO_2 in se osredotočili na trdne industrijske laserje srednje moči, so bili močno povezani z zgoraj omenjenimi sklepi, ki zadevajo lasersko industrijo. Prvič, stroški za razvoj in raziskave za trdne in plinske laserje CO_2 so postali zelo veliki. Drugič, program CO_2 je terjal zelo izrazit razvoj ne le laserske tehnologije, pač pa tudi njene uporabe. FOTONA se je odločila, da bi bilo, glede na to, da slovenske raziskovalne inštitucije in industrija niso dovolj vključene v uporabe te tehnologije, preveč tvegano tekmovati s svetovno lasersko industrijo, kjer so bile uporabe bolj razširjene zaradi močne kovinskopredelovalne industrije. V FOTONI smo se odločili, da se bomo oprli na industrijske laserje Nd:YAG srednje velikosti (serija YAG-22), kjer so različne vrste uporabe postale dokaj standardne in jih izvajajo lokalna podjetja. Tako v FOTONI razvijamo in izdelujemo industrijske laserje kot standardne »čipe«, ki se jih da praktično vgraditi v vsak standardni laserski industrijski sistem. V FOTONI smo se odločili, da bomo iskali strateške partnerje, ki obvladujejo uporabo ne pa tudi izdelave laserjev. Pred kratkim smo na primer podpisali dolgoročno pogodbo z vodilnim nemškim opremljevalcem zobozdravstvenih laboratorijev, BEGO, da bomo zanj razvili in izdelovali varilne laserje Nd:YAG.

10% of its revenue in R&D. For this reason, research expenditures in most developed countries are shared by state funded projects carried out by universities and research institutes. Without state funded research the laser industry would be unable profitably to develop new applications of laser technology. Cooperation between the industry and universities and research institutes brings another dimension to the business. Namely, the interests and goals of research institutions are often quite different from the interests and time horizons of industry. For this reason, industrial R&D groups must be highly educated and experienced in basic research in order to be able to communicate with university research groups and, in many instances, to take the initiative in research projects.

4 FOTONA: MEDICAL AND INDUSTRIAL PROGRAM

FOTONA became involved in industrial laser technology when the decision was made in the late 70 s to develop and produce high power CO_2 lasers mainly for cutting metals. By 1990, FOTONA's program included several types of large CO_2 laser systems (up to 600 W laser power) and medium power Nd:Y AG lasers (50W) with systems installed in what was then Yugoslavia, Eastern Europe and China. The reason that FOTONA decided to discontinue its CO_2 program and to concentrate on medium power solid-state industrial lasers in 1991 was very closely connected with the above conclusions concerning the laser industry. First, R&D expenditures in both, solid-state and CO_2 gas technology, were becoming formidable. Second, the CO_2 program required a very strong involvement not only in laser technology but also in the applications of this technology. FOTONA decided that since Slovenian research institutions and industry were not sufficiently involved in the applications of this technology, it would be too risky to compete with the world-wide laser industry where the applications were fueled by interest from the large metal processing industry. Instead, FOTONA decided to concentrate on medium scale Nd:YAG industrial lasers (YAG-22 series), where the applications have become quite standard and carried out by local companies. FOTONA thus develops and produces lasers as standard »chips« which can be build into practically any standard laser industrial system. FOTONA also decided to seek strategic partnerships with applications oriented non-laser companies. For example, Fotona recently signed a long term contract with a leading German supplier of dental laboratories, BEGO, to develop and produce Nd:YAG welding lasers.

V FOTONI smo se začeli ukvarjati s tehnologijo laserjev že v zgodnjih osemdesetih letih. Naše prve dejavnosti so vključevale dobavo laserskih izvorov Nd:YAG velikim izdelovalcem medicinske opreme, kakršni sta Laser Industries–Sharplan (Izrael) in Aesculab Meditec (Nemčija). Ti laserji so temeljili na poslih OEM, vgrajeni naj bi bili v končne izdelke (sisteme). FOTONA je dobavila 700 takšnih laserjev, ki se uporabljajo v ambulantah in bolnišnicah po vsem svetu. Leta 1991 je FOTONA razvila svoj lastni oftalmološki laserski sistem Nd:YAG MICROYAG, ki se je pojavil na trgu in prodajal pod lastno blagovno znamko ali pod znamko znanega nemškega optičnega podjetja Rodenstock. Do danes je po svetu vgrajenih prek 70 FOTONINIH oftalmoloških laserskih sistemov, na primer v Nemčiji, Južni Afriki in na Japonskem.

5 ZOBNI LASER TWINLIGHT: ŠTUDIJA PRIMERA

Ko se je FOTONA začela pojavljati na trgu oftalmoloških laserjev, je bila uporaba laserjev Nd:YAG v oftalmologiji že dobro sprejeta. Dejansko je oftalmologija edino zdravstveno področje, na katerega je laserska tehnologija prodrla več ko 95-odstotno. Zato se je lahko FOTONA v glavnem usmerila na lasersko tehnologijo in ne toliko na samo medicinsko uporabo (sekundarna katarakta), ki je bila že dobro raziskana in dokumentirana. V FOTONI smo tako lahko izboljšali lasersko tehnologijo in razvili po našem mnenju najbolj natančen laserski oftalmološki instrument Nd:YAG, kakor so pokazali klinični testi na Univerzitetni očesni kliniki v Ljubljani in na Inštitutu za očesno mikrokirurgijo v Moskvi [2].

Stanje na področju laserskega zobozdravstva pa je bilo popolnoma drugačno.

Od vsega začetka FOTONA namenja veliko pozornost raziskavam in razvoju novih vrst laserjev. Večina laserskih projektov je bilo izvedenih v sodelovanju z mednarodnimi raziskovalnimi institucijami, na primer University of California v Berkleyju v ZDA ali Tehnološki inštitut Fraunhofer v Aachnu v Nemčiji [3], [4]. To je omogočilo, da smo v FOTONI že zelo zgodaj spoznali, da razvoj novih laserskih tehnologij proti koncu 80. let omogoča širok razpon novih uporab v zdravstvu. Možnosti uporabe v zobozdravstvu so bile še posebej vzpodbudne in obetajoče. Ker je bil takrat prodor laserske tehnologije v zobozdravstvu razmeroma majhen, smo se v FOTONI zavedali, da bomo morali sodelovati kot eden od začetnikov pri razvoju novih laserskih industrij in uporab na področju zobozdravstva.

FOTONA' s involvement in medical laser technology also dates back to the early 80's. Its first activities were the supply of Nd:YAG lasers to large medical equipment producers, such as Laser Industries-Sharplan (Israel), and Aesculab Meditec (Germany). These lasers were based on OEM business, meant for being built into final products (systems). FOTONA has supplied approximately 700 lasers of this kind, which are used in outpatients clinics and hospitals all over the world. In 1991, Fotona developed its own ophthalmic Nd:YAG laser system, MICROYAG, which has been marketed and sold either under its own brand name or under the name of the well known German optics company, Roddenstock. To date, over 70 of FOTONA's ophthalmic laser systems have been installed world-wide, for example in Germany, South Africa, and Japan.

5 DENTAL LASER TWINLIGHT: A CASE STUDY

When FOTONA became involved in the ophthalmic laser market, the application of Nd:YAG lasers in ophthalmology had already been well accepted. Actually, ophthalmology is the only medical field in which the present penetration of laser technology is over 95%. For this reason, FOTONA could concentrate mainly on the laser technology and not so much on the medical application itself (posterior capsulotomy) which was already well investigated and reported. FOTONA was thus able to improve the laser technology and to develop what we believe to be the least invasive Nd:YAG laser ophtalmic instrument, as demonstrated by clinical tests at the University Ophthalmological Clinic of Ljubljana and Institute of Eye Microsurgery in Moscow [2].

The situation has been quite different with involvement in the laser dentistry.

Throughout its existence, FOTONA has been committed to research and development of new types of lasers. Many of the laser projects have been carried out in conjunction with international research institutions, such as the University of California in Berkeley, USA, or Fraunhofer Institute of Technology in Aachen, Germany [3], [4]. This enabled FOTONA to recognize very early that the emergence of new laser technologies in the late 80 s held promise of a wide range of new applications in medicine. Application possibilities in dentistry were particularly exciting and promising. Since at that time the penetration of laser technology in dentistry was relatively small, FOTONA was aware that it would have to participate as one of the pioneers in the development of new dental laser technologies and applications.

V FOTONI smo se lotili dela zelo sistematično. Najeli smo Laserski medicinski center v Berlinu v Nemčiji, da bi izvedli analizo objavljenih raziskav v laserskem zobozdravstvu. Poleg tega smo sprožili skupno raziskavo v sodelovanju z Ulmsko univerzo v Nemčiji in z Univerzitetno stomatološko kliniko v Ljubljani, da bi izvedli študijo učinkov CO_2 in laserskih žarkov Er:YAG na trda zobna tkiva (terapija in preprečevanje zobne gnilobe, površinska obdelava sklenine, endodontija, periodontija, kirurgija na mehkem tkivu, osteotomija). Pri tem smo uporabljali valovni dolžini Nd:YAG in Er:YAG. Še posebej zanimivi so bili rezultati raziskave, ki je pokazala, da je lahko laser Er:YAG učinkovit »nevsiljiv« nadomestek za standardno mehansko vrtanje.

V FOTONI smo se odločili, da bomo razvili nov zobni laser, ki bi lahko delal pri dveh valovnih dolžinah, Nd:YAG (1,06 μm) in Er:YAG (2,94 μm). Izziv je bil dvojen: a) razviti aparat, ki bi postavil nov tehnični standard v laserskem zobozdravstvu in b) razviti varen in učinkovit zobni laser. FOTONA je bila tako v sodelovanju z Univerzitetno stomatološko kliniko v Ljubljani in Univerzo v Ljubljani vključena v vrsto raziskav o vplivih laserskega sevanja na zobno tkivo [6] do [9]. Natančno smo upoštevali naslednji vrstni red: začetno raziskavo, kateri je sledila raziskava na živalih in na koncu pazljive klinične raziskave. Da bi optimizirali laserski izvor, smo izvedli raziskavo lastnosti materialov s primesmi ionov Er v sodelovanju z Inštitutom Jožef Štefan v Ljubljani [10] do [15].

Rezultat projekta je bil zobni laser TWINLIGHT z »dvema laserjema v enem«. Zobozdravniki so ta laser zelo dobro sprejeli. Odkar je instrument dobil prvo odobritev za uporabo v Nemčiji maja 94, so po vsem svetu vgradili prek 100 TWINLIGHTOV, na primer v Nemčiji, Angliji, Belgiji, Avstriji, Koreji, na Slovaškem, Madžarskem in v Sloveniji.

Pomembno je, da so bili zobozdravniki že od samega začetka vključeni v razvojni proces. Razvili smo posebno, po vsem svetu zaščiteno ergonomsko obliko instrumenta TWINLIGHT, ki olajša uporabo dveh laserskih valovnih dolžin. Instrument vključuje za uporabnika pripraven zaslon, izbor funkcij in sprejete zdravstvene podatkovne baze. Ker je razvoj nevsakdanjih zobnih uporab neprenehno ustvarjalen proces, zasnova instrumenta omogoča, da s preprosto zamenjavo programske opreme na laserjih stare generacije dobimo za uporabnika bolj prijetne izbore in informacije o novih medicinskih uporabah. Razvoj pa se ni ustavil. Trenutno razvijamo bolj prilagodljiv optični valovod Er:YAG, da bi ga lahko sedanji in prihodnji uporabniki laže uporabljali [16]. Potekajo tudi študije za povečanje hitrosti vrtanja z laserjem v še varnih mejah laserske moči [17].

FOTONA started very systematically, by hiring Laser Medizine Zentrum in Berlin, Germany, to carry out an analysis of published research in - laser dentistry. In addition, a joint research investigation was initiated together with the University of Ulm in Germany, and the University Dental Clinic in Ljubljana, in order to carry out a study of the effects of CO_2 and Er:YAG laser radiations on hard dental tissues [5]. The analysis revealed that most of the applications in soft and hard dental tissues (caries therapy, caries prevention, enamel conditioning, endodontics, periodontics, soft tissue surgery, osteotomy) were covered by Nd: YAG and Er:YAG laser wavelengths. Particularly exciting were research results that showed that Er:YAG laser could be an effective »non-invasive« alternative to the standard mechanical drill.

FOTONA decided to develop a novel dental laser which would operate at two laser wavelengths, Nd:YAG (1.06 μm) and Er:YAG (2.94 μm). The challenge was twofold: a) to develop an apparatus that would set a new technical standard in laser dentistry, and b) to develop safe and effective dental laser application protocols. FOTONA thus became involved, in cooperation with the University Dental Clinic in Ljubljana, and the University of Ljubljana, in a series of investigations of the influence of laser radiation on dental tissue [6] to [9]. The following sequence has been strictly followed: initial in vitro research, continued by in vivo animal studies, and finally careful clinical investigations. In addition, in order to optimize the source itself, research of the properties of Er doped laser materials has been carried out in collaboration with the Institute Josef Stefan in Ljubljana [10] to [15].

The project resulted in a dental laser apparatus TWINLIGHT, with »two lasers in one«. The laser has been very well accepted by the practicing dential community. Since the instrument obtained first approval for use in Germany in May 1994, over 100 TWINLIGHTs have been installed world-wide, for example in Germany, England, Belgium, Austria, Korea, Slovakia, Hungary, and Slovenia.

From early on, practitioners were involved in the process in order to provide insight into dental practice. A proprietary TWINLIGHT model design was developed in order to facilitate comfortable use of two laser wavelengths. Special attention was also given to the design of the dentist /laser system interface. This includes a user friendly screen, menu-driven applications, and accepted medical protocol databases. Since the development of non-conventional dental applications is an on-going creative process this allows, by a simple exchange of software, to »retro-fit« newer, more friendly menus and medical protocols to older generation lasers. Continuing efforts are under way to develop more flexible Er:YAG optical waveguides to offer existing and new users even more flexibility and ease of use [16]. Studies are also under way to increase the laser drilling speed within safe laser power limits [17].

6 SKLEPI

Razvoj nekonvencionalnih tehnologij spremlja vrsta izzivov. Pri primeru razvoja zobnega laserja je bil izziv združiti lasersko industrijo, vladne agencije, lasersko fiziko, medicinske raziskave, zobozdravnike in bolnike. Rezultat aktivnega vključevanja vseh petih sodelujočih je bil nekonvencionalen zdravstveni laser, ki ponuja nove možnosti in zmožnosti v vsakdanjem zobozdravstvu. Verjamemo, da bo klinična uporaba laserjev korenito spremenila zobozdravstvo, saj se čedalje več zobozdravnikov zateka k uporabi novo nastajajoče tehnologije.

6 CONCLUSIONS

The development of non-conventional technologies involves a range of challenges. In the case of the development of the dental laser, the challenge has been to bring together the laser industry, government agencies, the laser physics community, the medical research community, practitioners, and patients. The active involvement of all five communities has resulted in a non-conventional medical laser which offers new possibilities and capabilities in everyday dentistry. We believe the clinical application of lasers will revolutionize dental care as an increasing number of dentists adopt this emerging technology.

7 LITERATURA
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