2.94 μm Er:YAG laser Q-switched with RTP Pockels cell

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A growing interest in high power lasers operating in the middle infrared spectral range – especially near 3 μm – has been observed recently. In this spectral area an extreme value of the absorption coefficient in water (above 10^4 cm^{-1}) as well as in hard and soft biological tissues has been noticed. Although for such strong absorption of powerful laser pulses ablation is a dominant mechanism of interaction of the laser beam with the tissue nevertheless any thermal effects causing the damage of cells around the interaction area have been appeared. Even thought these parasitic effects are the weakest for the laser operating at 3 μm they can not be ignored completely for free running regime when pulsewidth exceeds hundreds of μs. One of possible solutions leading to the elimination of such thermal effects is the application of Q-switched lasers emitting at 3μm – Er:YAG laser, for instance.

A variety of different Q-switching techniques have been used in Er:YAG laser up to now [1]. Among them we can mention the following: mechanical Q-switching with rotating mirror (prism), electrooptical Q-switching using $LiNbO_3$ Pockels cell, acoustical-optical Q-switching, passive Q-switching by thin water layers or Q-switching with a Q-switch utilizing frustrated total internal reflection.

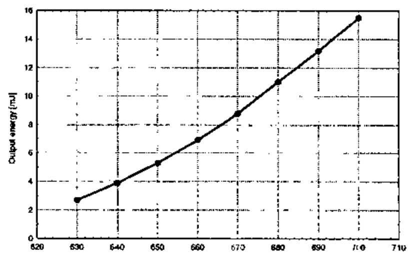

Fig.1. Output energy of Q-switched Er:YAG laser vs applied supply unit voltage.

I our work for the first time we have used a Q-switch based on RTP ($RbTiOPO_4$) crystal in the Er:YAG laser operating at 2.94 μm. This crystal is characterized by an excellent transparency up to 4.3 μm, high electrical resistivity (a few orders of magnitude higher than KTP) and quite high damage threshold (1.8 GW/cm^2) [2]. Moreover, it is temperature stable, is not hygroscopic and does not show piezoelectric ringing. These features cause that RTP is an ideal candidate as the effective Q-switch for Er:YAG laser.

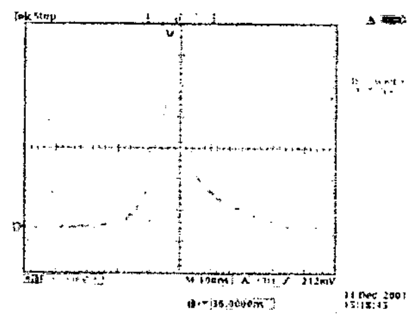

Fig.2. The oscilloscope trace of Er:YAG laser pulse obtained with Molectron P3-02 probe

A thermally compensated (double crystal) RTP Pockels cell, in a quarter-wave configuration, operating in a transverse electrode orientation with the light propagating along the optical axis was applied in our laser. A single PLZT ceramic Brewster orientated plate was used as a polarizing element. The Pockels cell was delivered from Raicol Crystals Ltd (Israel). An erbium doped YAG rod with 4 mm of diameter and 100 mm length mounted in the lamp pumped cavity type LMI 1610 was used as a lasing medium. Two flat mirrors formed an optical resonator which length was 42 cm. Output mirror reflectivity was 70%. For such configuration over 15 mJ of the output energy was achieved for the optimal repetition rate of 10 Hz and maximal pumping energy of 62 J. At the same time the shortest and the strongest powerful giant pulse with 115 ns FWHM was generated giving about 130 kW of the peak pulse power.

One preliminary experiment of the interaction of 2.94 μm giant laser pulses with the biological tissue was carried out. Non of the thermal effects was observed in this case whereas significant coagulation was noticeable when the laser operated in free running regime.

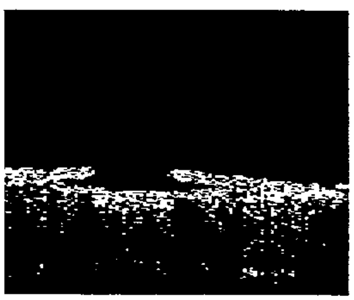

Fig.3. OCT picture of the eye lens tissue after illumination of the free running Er:YAG laser

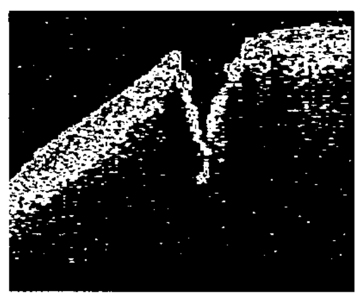

Fig.4. The same but irradiated with ns pulse of the Er:YAG laser at 2.94 μm.

References

1. H. Jelinkova, M. Nemec, J. Sulc, M. Cech, M. Ozolinsh, Er:YAG laser giant pulse generation, *Laser Florence 2001 Conference Proceedings*
2. E. Lebiush, R. Lavi, Y. Tsuk, N. Angert, A. Gachechiladze, M. Tseitlin, A. Zharov and M. Roth, RTP as a Q-switch for high repetition rate applications, *ASSL 2000*