Medical Devices with Fiber Lasers and their Applications.

Vladimir P. Minaev  
NTO “IRE-Polus”  
Fryazino, Russia  
vMinaev@ntoire-polus.ru

Abstract— There is presented information on medical laser devices used fiber lasers with wavelengths 1.06; 1.45; 1.56; 1.68, 1.9 μm and examples of medical techniques, used this devices

Keywords— fiber lasers, lasers in medicine.

Medical devices with fiber lasers allows to realize a number of advantages: to increase reliability, to reduce weight, dimensions and power consumption, to use the output fibers with small diameters. But the main advantage is possibility to have working radiation wavelengths and the temporary regimes with different parameters of action on biological objects. It, in turn allows to optimize various medical technologies [1]. Fiber lasers allowed to develope also the devices providing two independently adjustable radiations with different wavelengths in one working fiber.

The results of laser action on biotissue strongly depends on the laser radiation absorption μa, in the main chromophores - water and hemoglobin. Absorption coefficients values μa, for water and whole blood, and also a difference between these values for some wavelengths are presented in table 1. This allows to estimate absorption in hemoglobin for wavelengths λ, corresponding to various fiber lasers used in medical devices for surgery and forced therapy.

<table>
<thead>
<tr>
<th>Laser</th>
<th>Diode: Yb</th>
<th>Raman</th>
<th>Er</th>
<th>Raman</th>
<th>Tm</th>
</tr>
</thead>
<tbody>
<tr>
<td>λ, μm</td>
<td>0.94-0.98</td>
<td>1.03-1.08</td>
<td>1.41-1.47</td>
<td>1.55-1.57</td>
<td>1.68</td>
</tr>
<tr>
<td>Jλ, water, mm-l</td>
<td>0.05</td>
<td>0.015</td>
<td>3</td>
<td>1</td>
<td>0.68</td>
</tr>
<tr>
<td>Jλ, blood</td>
<td>0.85</td>
<td>0.545</td>
<td>5</td>
<td>1.4</td>
<td>0.16</td>
</tr>
<tr>
<td>Pmax, Br</td>
<td>300</td>
<td>10(250)</td>
<td>30</td>
<td>50</td>
<td>12</td>
</tr>
</tbody>
</table>

The first of fiber lasers in medical devices were lasers with the Er-doped fiber (λ ≈ 1,56 μm) which were successfully used for treatment the spinal disks diseases, corrections of nose septum and wings form, a revascularization of myocardium, for rejuvenation of skin (devices "Fraxel"), treatments of vascular malformations (large cystic hemangiomas and limphangiomas) and endovenous laser treatment (EVLT) of safenous vein reflux.

A little later interest to radiation strongly absorbed in biotissues with λ = 1,94 μm (lasers with the Tm-doped fiber) was shown. They are successfully used in ENT surgery, dentistry, for treatment of bones diseases by a method of laser osteoperforation, for vaporization and enukleation of prostate tumors.

In several devices this radiation is used with a radiation of 1,55 μm or 1,47 μm (the Raman fiber lasers) for rejuvenation of skin, removal of prostate tumors. However the device of 1,56+0,97 μm, allowed to realize highly effective technique of simultaneous treatment the ENT diseases, was the first two-wave device with the fiber laser.

Radiation with a wavelength 1,68 μm is perspective for use in the techniques, which needs warming of large volumes of biotissue without carbonization, for example, for laser interstitial thermotherapy. Now there are performed experiments on use of such radiation for correction of a breast cartilage shape by a laser thermoplastics method.

The listed doesn't exhaust opportunities of fiber lasers. There are in turn medical devices with already developed fiber lasers of visible range with wavelength of 0,59(589) μm and 0,53 μm, pulse and periodic lasers with the small duration of impulses.


Lasers with the Yb-activated fiber (λ = 1,06 μm) weren't widely used because of the competition of simpler devices with diode lasers.