

LASER APPLICATIONS IN MEDICAL DIAGNOSTICS

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This work is devoted to the usage of modern laser technologies in medicine. The most informative laser diagnostic methods include optical coherence tomography, Raman spectroscopy, and laser Doppler flowmetry, which provide high-resolution imaging and detailed analysis of biological tissues. The high accuracy, maximum safety and minimal invasiveness of laser technologies provide them with a significant role in medical diagnostics, not only improving diagnostics, but also facilitating early detection of diseases, which significantly increases the chances of successful treatment and improves the patients' quality of life.

Modern medicine is actively introducing advanced technologies to boost the diagnosis and treatment of diseases, a great example for this is the application of lasers, which due to their unique features allow to perform precise and low-invasive medical procedures, which significantly reduces the patient's recovery time and minimizes the risk of complications.

When using lasers in medicine, it is crucial to consider how laser radiation interacts with biological tissues, primarily through scattering, absorption, and fluorescence processes. For example, as a laser beam passes through the skin, part of it scatters, another part is absorbed by pigments (such as melanin and hemoglobin), and the remaining portion may induce fluorescence, which is used to diagnose pathological changes [1].

One of the most informative laser-based diagnostic methods is Optical Coherence Tomography (OCT), which is based on the interference of coherent radiation. This method provides high-resolution imaging of biological tissues. In ophthalmology, OCT is used to diagnose retinal diseases, detect glaucoma, and assess the condition of the optic nerve [2]. In cardiology, it is applied to study vascular structures and detect atherosclerotic plaques at an early stage. In dermatology, it allows for the analysis of skin conditions and the diagnosis of malignant tumors without invasive procedures. Laser spectroscopy is also widely used for studying the composition of biological tissues and fluids.

Another innovative method is Raman spectroscopy, which makes it possible to detect molecular changes in cells and tissues, thereby enabling high-resolution imaging of biological structures. Fluorescence spectroscopy, on its turn, helps to detect pathological changes in tissues by analyzing their fluorescence under the influence of laser, which is used to diagnose precancerous conditions of mucous coatings and detect infectious diseases at early stages [3].

Laser Doppler Flowmetry (LDF) is employed to assess blood microcirculation, utilizing the Doppler effect: laser radiation reflects off moving red blood cells, and by analyzing changes in the frequency of the reflected signal, blood flow velocity can be determined. LDF is widely used in diagnosing vascular disorders, including diabetic angiopathy, chronic venous insufficiency, and trophic ulcers.

As the technology continues to evolve, laser applications are opening up new possibilities for the future, of which one of the most promising is the development of compact and portable laser systems that will allow laser diagnostics to be used not only in specialized clinics, but also in ambulatory environments, at home, and even in the battlefield. What is more extraordinary, and relevant to real time, is the integration of laser technology with artificial intelligence, which will automatically analyze and organize data, improve diagnostic accuracy and reduce the workload of the doctors.

Besides, nanoparticles (such as gold and silver) represent another medical innovation that improves tumor detection: gold nanoparticles can accumulate in the malignancies, thereby enhancing the interaction of laser light with the damaged tissues, making visualization much easier and more accurate [4].

Taking everything into consideration, laser technology already plays a significant role in medical diagnostics, providing high accuracy, safety and minimal invasiveness, while their future development, including miniaturization of devices, integration of artificial intelligence and the use of nanoparticles, will make laser diagnostics even more accessible and effective. These technologies not only improve diagnostics but also facilitate early disease detection, significantly increasing the chances of successful treatment and improving patients' quality of life.

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