Medical applications of sapphire shaped crystals combined with measurement of spatially resolved diffuse reflectance

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Sapphire possesses a number of remarkable properties, such as high hardness, mechanical strength, biocompatibility, chemical inertness, thermal resistance, high thermal conductivity at cryogenic temperatures, and high optical transparency in visible and near infrared ranges. This makes sapphire suitable for for manufacturing of medical instruments for laser therapy and diagnosis, as well as for tissue resection and cryodestruction [1-4]. Using the techniques for sapphire shaped crystal growth from melt [5-7], it is possible to make crystals with internal capillary channels that enable diffuse reflectance measurement by accommodating optical fibers inside these channels.

The sapphire scalpels and probes use diffuse reflectance for monitoring of tissue type and condition. The scalpel helps to detect tumorous tissue region during resection by providing fluorescence and diffuse reflectance signals [8]. The sapphire cryoprobe enables detection of tissue freezing depth during cryosurgery by either spatially resolved frequency-domain or stable-state diffuse reflectance measurements [9]. Another compact sapphire probe was tested for monitoring of circulatory disorder in muscle tissue. It can detect the alteration of the extinction coefficient of damaged tissue. This instrument can be further used for intraoperational noninvasive monitoring of tissue transplantation.

The common advantage of these sapphire instruments is their compactness and ability to perform laser coagulation in addition to the described modalities. In the present work, the problems of manufacturing of these instruments, theoretical aspects of estimation of tissue properties and particular examples of the applications of these instruments are discussed.

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