Biomedical applications of sapphire shaped crystals

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***Abstract*—We have proposed novel medical instruments based on sapphire shaped crystals fabricated using the edge-defined film-fed growth (EFG) or related techniques. Due to the favorable combination of the unique properties of sapphire (high thermal strength and mechanical hardness, impressive melting point and chemical resistance, transparency in a wide spectral range) the developed instruments could help to solve numerous important problems of medical diagnosis, therapy, and surgery.**

Keywords—sapphire shaped crystals, Stepanov method, edge-defined film-fed (EFG) technique, medical diagnosis, therapy and surgery.

I. Introduction

For a wide range of crystals, it is rather difficult to shape the crystalline media using conventional techniques of mechanical processing, such as drilling or polishing, owing to its high hardness and anisotropy of physical properties. Therefore, various methods to grow shaped crystals directly from the melt have been proposed [1]. Among them is edge-defined film-fed growth (EFG) technique, which relies on Stepanov's concept and allows for manufacturing the sapphire shaped crystals of almost any predetermined cross-section [2–7]. Due to the favorable combination of the unique properties of sapphire (high thermal strength and mechanical hardness, impressive melting point and chemical resistance, inertness to the human blood and body fluids, transparency in a wide range of electromagnetic spectrum) [1] the sapphire shaped crystals allow for solution numerous important issues of medical diagnosis, therapy, and surgery [8].

II. Results

We developed novel medical instruments based on sapphire shaped crystals, fabricated by the EFG or related techniques. Among these instruments we would particularly present:

- *sapphire needles*, which allow for delivery laser radiation into a tumor in the course of interstitial photodynamic therapy, thermotherapy, and tissue coagulation [9];
- *sapphire scalpels,* which allow for combination the intraoperative optical diagnosis and resection of tissues with the concurrent laser coagulation of nearby blood vessels [10];
- *sapphire neuroprobes*, which allow for combination the aspiration of malignant brain tissues with the intraoperative optical diagnosis and laser coagulation of nearby blood vessels [11,12];
- *sapphire cryoapplicators*, which allow for performing the tumor cryosurgery with the laser control of the temperature regimes and the optical diagnosis of the ice ball formation [13,14].

We performed numerical simulations and experimental studies using either the tissue phantoms or the tissues *ex vivo* in order to demonstrate the promising sapphire instruments for medical diagnosis, therapy, and surgery.

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