UFE Institute of Photonics and Electronics
The Czech Academy of Sciences

Review of doctoral thesis

Author: **Mgr. Fangxin Yue**

Title: **Development of a cryogenic 2 μm multi-pass amplifier in nanosecond regime**

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Topicality of the subject

The solid-state lasers represent the fundamental photonic devices with high application value. To improve the laser properties and extend the application potential, the novel active materials and laser designs are in the scope of photonics research. Advanced technological approaches provided a new class of transparent ceramic luminophores representing an economical alternative to conventional single crystals as the laser media. In the thesis, the author realized experimental research of Tm:Y2O3 transparent ceramic as an active medium in cryogenic amplifiers operating at 2 μm in the nanosecond regime.

Methods

The thesis is well-structured and organized in 7 chapters. Chapter 1 presents a comprehensive state of the art. Chapters 2 and 3 target structural and spectroscopic characterizations of Tm:Y_2O_3 transparent ceramic with a particular focus on optical properties. The acquired data are used in Chapters 4, 5, and 6 to successfully construct a continuous-wave laser, cryogenic master oscillator and cryogenic multi-pass amplifier. Chapter 7 summarizes the achieved results.

The research strategy was well planned and the authors provided sufficient description of the applied methods, experimental set-ups, and devices. The structural characterization of Tm:Y_2O_3 transparent ceramic samples should be provided in more detail to prove the regular distribution of Tm^{3+} ions in Y_2O_3. This is a minor task because the main thesis objective targets the design of cryogenic amplifiers.

However, the thesis significantly suffers from poor formatting and non-uniform style. Although the chapters start with a brief paragraph summarizing the experimental methods,

some of the used devices are randomly introduced in the section focused on results and discussion. The figures' format is non-unified and widely does not match the common publication standards, e.g. notification of the compound figures. The combination of several types of units for identical quantities makes the text hard to understand, as can be seen at the temperature given in degrees Celsius and Kelvins. The units "a.u." are incorrectly used to denote the normalized intensity.

Novelty of the results and scientific impact

The author significantly contributed to the research of novel solid-state cryogenic amplifiers. The detail spectroscopic study on bulk Tm:Y_2O_3 transparent ceramic provided information that are fundamental for the design of active optical devices operating at 2 μm. The results proved the concept of bulk Tm:Y_2O_3 transparent ceramic as active medium in cryogenic continuous wave laser. The author designed and constructed a multi pass amplifier with tailored properties and improved peak power up to 174 kW. The applied material can be simply varied and the proposed methodology can be further extended allowing the qualitative improvement of the laser properties.

Mgr. Fangxin Yue successfully published the main results in 2 scientific journals and one proceeding as a principal author. Her research contributed to other 8 papers published in impacted journals and 2 conference proceedings. Extensive co-operation between three research institutions, including the foreign partner, significantly extends the prestige of the work proving author management skills.

Remarks and questions

Considering the research topic, I would like to ask the author to answer several questions:

1. In chapter 2, page 18, the author explains the variation of the shades in SEM image by the presence of Tm_2O_3 phase. How can the existence of such a phase contribute to the luminescence intensity and sample decay time?

2. The time dependence of the luminescence lifetimes is demonstrated in Figure 3-18, page 44. Can you demonstrate the time decay curves of analyzed samples? Are the decay curves single-exponential or do they exhibit multicomponent behavior?

3. As was demonstrated in chapter 4, page 60 the sample containing 5% of Tm^{3+} ions exhibited higher slope efficiency than the sample containing 3% of Tm^{3+} ions. Does the efficiency increased linearly with the concentration of Tm^{3+} ions or can an optimal concentration of Tm^{3+} ions be found?

4. The sample size was quite large, how was the diameter of the output laser beam?

Conclusions

The author has proven the ability of independent scientific work, including the dissemination of the achieved results. He fulfilled the declared thesis' objectives, i.e. to evaluate the properties of $Tm:Y_2O_3$ transparent ceramic, to construct a laser oscillator with tunable repetition rate, and to apply $Tm:Y_2O_3$ as an active medium in the cryogenic multi-pass amplifier. I do recommend the doctoral thesis for presentation with the aim of receiving the Degree of Ph.D.

In Prague, 3rd May 2021

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