Development of micro-pulling-down method for growth of oxide and halide single crystals

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The micro-pulling-down (μ-PD) technique is a new crystal growth method from the melt, which has been developed since 1992. The term "pulling-down" represents the direction of solidification and "micro" reflects the presence of microcapillary channel(s) about 0.2-2 mm in diameter at the bottom of the crucible [1]. The melt residing in a crucible is transported downward the microcapillary in the bottom of the crucible, where solidification and formation of the crystal-melt interface take place. Appropriate configuration of the crucible bottom and properly selected temperature gradient allow to control the crystal shape and the dimensions of the crystals cross section ranging from 0.1 to 10 mm. Yoon et al. [2] presented a first modern design of a resistively heated μ-PD apparatus created in Tohoku University, Japan, for the growth of $LiNbO_3$ thin-fiber crystals. Furthermore, a μ-PD prototype apparatus equipped with a radiofrequency inductive heat source for preparation of $Si_{1-x}Ge_x$ mixed crystals was reported by Koh and Fukuda [3]. In 1999, Yoshikawa et al. [4] reported on crystal growth of $Al_2O_3/Y_3Al_5O_{12}$ eutectic fibers using μ-PD apparatus equipped with Ir crucible placed on Ir afterheater with two windows for real-time observation with CCD camera. Significant contribution on adaptation of μ-PD apparatus for crystal growth of fluoride materials ($Ce:PrF_3$) was presented by Yoshikawa et al. [5]. The μ-PD apparatus was equipped with tight vacuum chamber, allowing evacuation of the system down to 10^{-5} Torr before crystal growth, CaF_2 window for direct observation, and carbon crucible and afterheater surrounded by refractory carbon as heat shield. In 2010, Yokota et al. [6] presented a development of μ-PD apparatus for preparation of hygroscopic halide crystals by adding a removable chamber into the growth arrangement. This chamber allowed its transportation into an atmosphere controlled glove box where an experimental setting and handling of starting materials was held. This contribution presents a review of the development of the μ-PD method used for preparation of oxide crystal growth and growth of materials with more demanding experimental arrangement. Recent results of new material conceptions for applications as radiation detectors or mid-IR lasers will be discussed.

The support of Czech Science Foundation grant No. 15-18300Y is gratefully acknowledged.

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