# Growth of $Li_4Mo_5O_{17}$ and $Na_6Mo_{11}O_{36}$ crystals by the low-thermal-gradient Czochralski technique for neutrinoless double beta-decay search

Grigorieva V.D.*, Shlegel V.N.
*unbiassed1@gmail.com, grigoryeva@niic.nsc.ru
1 Nikolaev Institute of Inorganic Chemistry, Russia

At present time neutrino is considered one of the most probable dark matter compounds. The search for neutrinoless double beta (0ν2β) decay is one of the major tasks of rare events physics since it's registration will determine the nature of the neutrino as Majorana particle and test the lepton number conservation law. Registration of 0ν2β decay will allow to calculate the neutrino energy and determine the neutrino mass [1].

0ν2β-decay is theoretically predicted for 35 nuclei, the most promising of which are molybdenum-100 ($^{100}Mo$), cadmium 116 ($^{116}Cd$) and selenium-82 ($^{82}Se$). Thus, molybdate-based crystalline scintillators are of great interest for large-scale neutrino search projects. The extreme rarity of double beta decay ($^{100}Mo$ nucleus half-decay time is estimated as ~$10^{28}$ years) imposes the strictest requirements on molybdate crystal scintillators used in projects. In addition to the general requirements for scintillators - high optical quality, luminescence intensity, light output, energy resolution, the material must also contain a minimum amount of impurities and have an ultra-low radiation background.

The low-thermal-gradient modification of Czochralski technique (LTG Cz) developed at NIIC SB RAS is a unique technology for obtaining large oxide crystals of high optical quality in bulk volume. LTG Cz has significant structural differences from the conventional Czochralski technique resulting in temperature gradients being reduced by two orders of magnitude to values less than 1 deg/cm. Thus, the processes of volatilization of the melt components are suppressed, the loss of expensive isotopically enriched molybdenum-100 during growth process is prevented, the number of thermoelastic stresses and defects in growing crystal is reduced.

Based on literature data, alkali metal polymolybdates $M^{+1}{}_xMo_yO_z$ are not hygroscopic, have a higher density and molybdenum content per unit volume than already developed molybdate scintillator $Li_2MoO_4$ [2]. The study of the phase diagrams of $Li_2O$-$MoO_3$, $Na_2O$-$MoO_3$ and $Cs_2O$-$MoO_3$ showed that intermediate compounds $M_xMo_yO_z$ melt congruently at temperatures below 1000 °C, thus, they fit into the paradigm of LTG Cz crystal growth.

Fig. 1. $Li_xMo_yO_z$ crystal

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**References (if needed)**

[1] Bekker T.B. Grigorieva V.D. et al. Aboveground test of an advanced $Li_2MoO_4$ scintillating bolometer to search for neutrinoless double beta decay of Mo-100» Astroparticle Physics, 2016, V. 72, pp. 38–45
[2] Pandey I.R, Grigorieva V.D. et al. The $Na_2W_2O_7$ crystal: a crystal scintillator for dark matter search experiment. European Physical Journal C, 2018, 78:973.