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A promising crystal laser matrix based on double halides.

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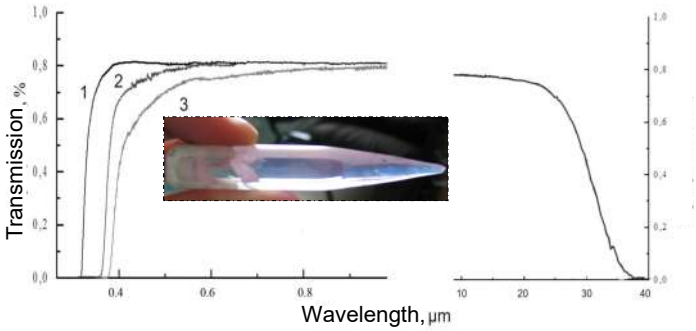
RE doped alkali-lead halide crystals of MPb_2Br_5 (M=K, Rb) attract attention due to a possibility of laser generation beyond the 4μm limit owing to their lower vibrational frequencies and higher quantum yields. MPb_2Hal_5 crystal matrixes are transparent in the UV to mid-IR spectral range (from 0.3 to 30 μm), have satisfactory mechanical properties, high chemical resistance, low hygroscopicity, extremely low maximum phonon energy (~200 cm^{-1} in chlorides and ~ 140 cm^{-1} in bromides) and as a result lower non-radiative rates.

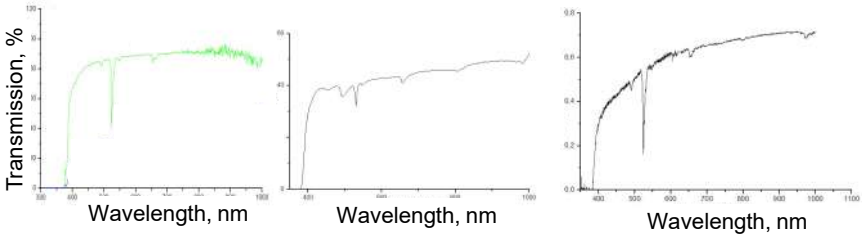
Double halides– effective materials for laser generation in mid IR region

Laser matrices based on double halides were grown by the vertical Bridgman method.



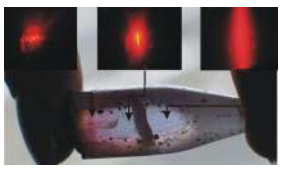
Crystal transmission spectra for $KPb_2Br:Er^{3+}$; $K_{0.5}Rb_{0.5}Pb_2Br_5:Er^{3+}$; $RbPb_2Br_5:Er^{3+}$

The use of this group of crystals as laser matrices is associated with a number of difficulties.

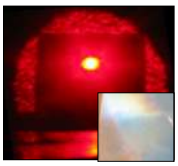


Transparency area : 1 – KPb_2Br_5; 2 – $RbPb_2Br_5$; 3 – $K_{0.5}Rb_{0.5}Pb_2Br_5$

The authors found that RPB crystals exhibit strong anisotropy of linear thermal expansion and pronounced anisotropy of optical properties. There is no such effect in KPB single crystals, which is due to the significant difference in the ratio between the unit cell parameters a,b / c, and a / c in KPB and RPB, respectively.



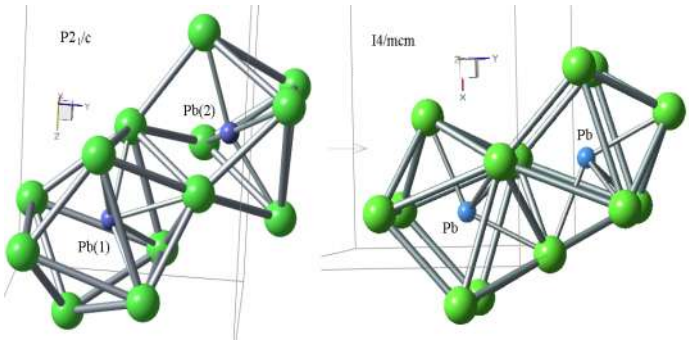
KPb_2Br_5 ($P2_1/c$)



$RbPb_2Br_5$ (I4/mcm)

$K_{0.5}Rb_{0.5}Pb_2Br_5$ ($P2_1/c$)

The crystal structure of KPb_2Br_5 (KPB) is monoclinic (P21/c) and contains 2 lead positions: with coordination numbers (CN) of 8 and 7 and lead ionic radii of 1.22 Å and 1.10 Å, respectively. The second position (R_{ion} = 1.10 Å) is the most suitable for entering of rare earth ions in the structure. But KPB crystals have a very poor optical quality due to a phase transition they undergo during growth.



Crystals of $RbPb_2Br_5$ (RPB) do not undergo phase transitions at temperatures below the melting point; therefore, they can be used to obtain elements of high quality and large size. The RPB structure is tetragonal (I4 / mcm), where Pb^{2+} ions occupy a single position with a CN = 8 and an ionic radius of 1.22 Å. The size of this position exceeds sufficiently the radii of rare-earth ions; therefore, the coefficient of their incorporation into the RPB lattice is low.

Coefficients (in 10^{-6} K^{-1}) of linear (αi) and volumetric (β) expansion of $K_xRb_{1-x}Pb_2Br$ crystals, where 0≤x≤1 in the temperature range 100-298K.

	$RbPb_2Br_5$	$K_{0.5}Rb_{0.5}Pb_2Br_5$	KPb_2Br_5
α_a	36	27	40
α_b	36	33	36
α_c	58	31	28
V	130	91	107

To obtain a more efficient material with an optimal set of characteristics, the authors obtained mixed $K_{0.5}Rb_{0.5}Pb_2Br_5$ crystals doped with rare earth elements. It was found that these crystals are characterized by the minimum anisotropy of thermal parameters and spectral properties along different crystallographic directions. Spectroscopic studies have shown that the transparency range and the dominance of the radiative relaxation mechanism in the range up to 10 microns, which are characteristic of pure compounds $RbPb_2Br_5$ and KPb_2Br_5, are preserved in $K_{0.5}Rb_{0.5}Pb_2Br_5$, and, therefore, it can be considered as a promising laser matrix for mid-IR.

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