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CHARACTERISTICS OF SINGLE CRYSTALS OF TETRAGONAL PHOSPHATES

INTRODUCTION

Single crystals in this group belong to the 42m symmetry and are isomorphous with KDP. There are three members, namely:

ADP:	Ammonium Dihydrogen Phosphate	$NH_2H_2PO_4$
KDP:	Potassium Dihydrogen Phosphate	KH_2PO_4
RDP:	Rubidium Dihydrogen Phosphate	RbH_2PO_4

These salts are soluble in water and single crystals are grown in a saturated solution of the salt. When these crystals are grown in heavy water (D_20) solution, the useful electro-optical properties are enhanced. In this case hydrogen is replaced by deuterium. The new crystal, of say KDP grown in D_20 is written as D-KDP; Potassium Dideuterium Phosphate KD_2PO_4. An asterisk is sometimes used to designate the prefix D, KD*P for D-KDP.

Quantum Technology is the first company to investigate the application of RDP crystals for sum frequency mixing (SFM). However, this material converts to an alternate crystal structure above 80°C. This is manifested by sudden fracture within the body of the crystal. It is an excellent frequency doubling crystal, for dye laser radiation at about 6300Å. Important physical and electro-optical properties are given in Table III and IV.

A lower temperature limit for SHG application is set by the Curie temperature. Below this temperature the crystals do not exhibit E-O effect and the antiferroelectric crystal ADP physically cracks at this temperature. The upper temperature limit is set by the chemical decomposition for the alkali metal salts. This does not occur below 200°C. However, it is noticeable for the ammonium salt at about 120°C. Resistivity of these salts depends upon metallic impurities. The temperature coefficient of resistivity is of the order of 3.5%/°C and is negative. This can lead to thermal runaway breakdown if high voltage is applied continuously.

These crystals are transparent in the range 240-1600nm (sample thickness 10mm). Deuteration increases the infrared limit to 1900nm. D-KDP crystals grown in crystallizers near room temperature are excellent for Q-switching. Since D-KDP can be oriented for Type II angle matching, it is equally attractive for SHG of Nd:YAG radiation. For frequency quadrupling crystal bars of ADP or KDP are favoured, since long (up to 60mm) 45°Z cut bars are available. Efficiency of over 30% is achieved by the use of longer bars. The crystal KDP is preferred for angle tuning since it is about 50% less sensitive to ambient temperature fluctuations as compared to ADP. The range 5160 Å to 7600 Å is usually covered by five different KDP crystals oriented for angle matching at 85°, 75°, 65°, 55°, and 45°. For more information, please refer to data sheet 706 for angle tuning and data sheets 704 and 707 for temperature tuning.

TABLE I

PHYSICAL PROPERTIES OF TETRAGONAL ARSENATES						
MATERIAL		**ADP**	**D-ADP**	**KDP**	**D-KDP**	**RDP**
PARAMETER						
DENSITY gm/cm^3		1.799	1.885	2.332	2.355	2.869
THERMAL EXPANSION 10^{-6}/°C from –50° to +50°C	∥c	4.2	-	44.0	40.7	45.8
	⊥c	32.0	-	24.9	20.1	22.3
THERMAL CONDUCTIVITY W/cm/°C at 25°C		-	-	0.019	0.019	-
SPECIFIC HEAT Cal/degree Mole at 25°C		33.9	-	28.0	-	34.0
RELATIVE DIELECTRIC CONSTANT AT 25°C, and at 1 KHz	K^T_{11}	56.0	72.0	42.0	65.0	42.0
	K^T_{33}	15.4	22.0	21.0	51.0	28.0
CURIE TEMPERATURE °K		147.0	242.0	122.0	222.0	147.1
SPECIFIC RESISITIVITY R_{33} ohm-cm at 25°C		$1.5x10^{10}$	-	$1.9x10^{10}$	$2.2x10^{10}$	$2.7x10^{10}$
90° PHASE MATCHING WAVELENGTH (nm) and TEMPERATURE °C	20°C	526	529	518	531	627
	100°C	548	554	522	536	637

TABLE III

ELECTRO-OPTICAL PROPERTIES OF TETRAGONAL PHOSPHATES							
MATERIAL			**ADP**	**D-ADP**	**KDP**	**D-KDP**	**RDP**
PARAMETER							
HALF-WAVE VOLTAGE $V_{\lambda/2}$kV at 546nm			9.0	6.55	7.65	2.98	5.15
ELECTRO-OPTIC CONSTANT 10^{-12} m/V at 546nm		r^T_{41}	+24.5	+55.5	+18.77	+ 8.8	+ 9.1
		r^T_{63}	- 8.56	-11.9	-10.3	-26.4	-14.0
REFRACTIVE INDICES at VARIOUS WAVELENGTHS (nm)	410	∩o	1.539	-	1.522	-	1.523
		∩e	1.490	-	1.479	-	1.492
	480	∩o	1.531	-	1.517	-	1.515
		∩e	1.484	-	1.474	-	1.485
	550	∩o	1.527	1.519	1.512	-	1.511
		∩e	1.481	1.478	1.470	-	1.481
	590	∩o	1.524	-	1.509	1.506	1.508
		∩e	1.479	-	1.468	1.467	1.480
	650	∩o	1.521	-	1.507	-	1.506
		∩e	1.476	-	1.467	-	1.477
NON-LINEAR SUSCEPTIBILITY d_{36} 10^{-12} m/V at WAVELENGTHS (nm)	694.3		0.49	-	0.47	0.50	0.43
	1060.4		0.56	-	0.47	0.50	-