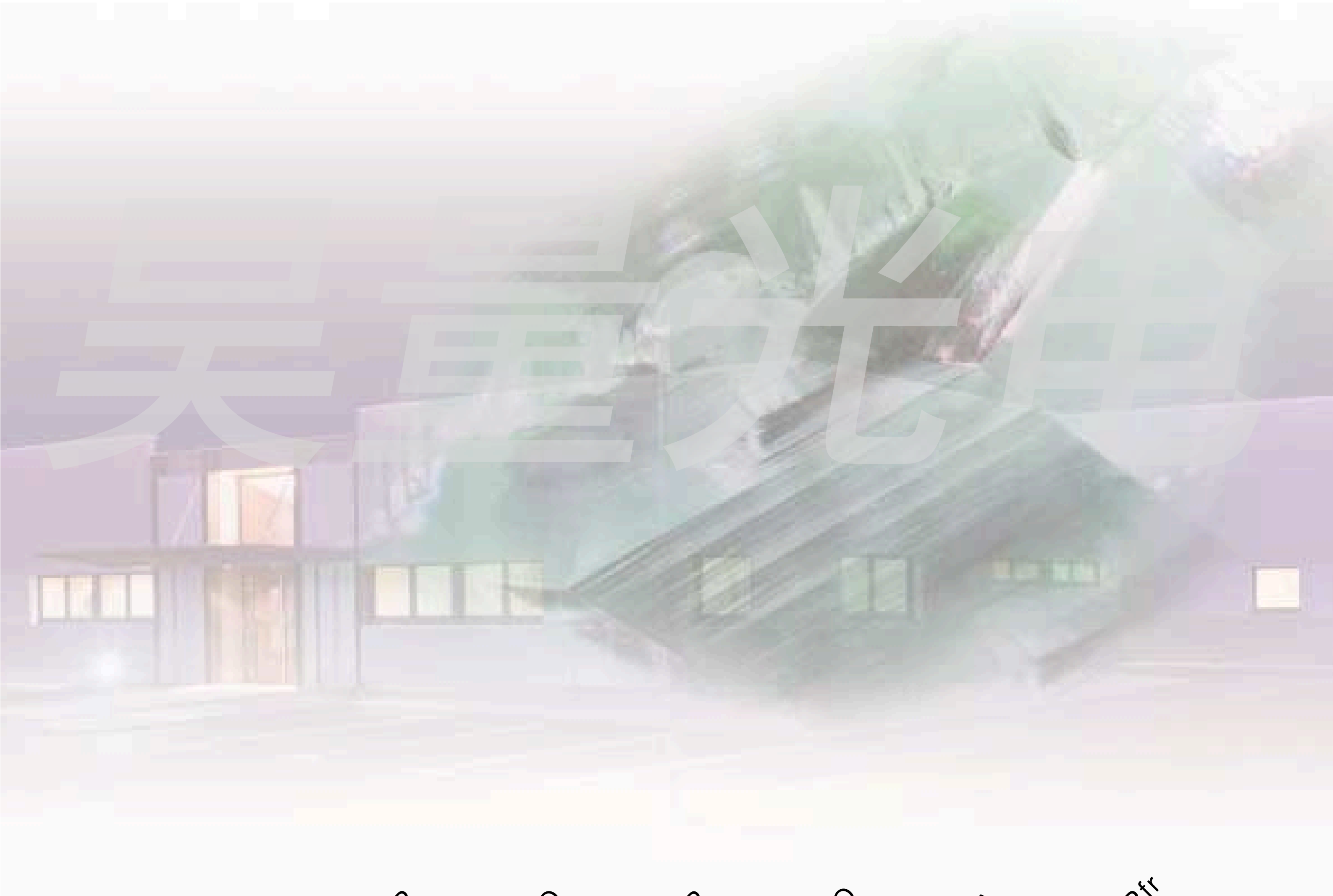
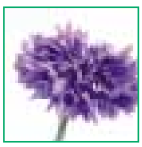
Product overview

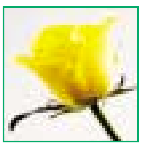


KTP

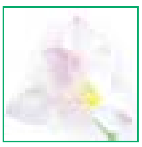
LBO



RTP



BBO



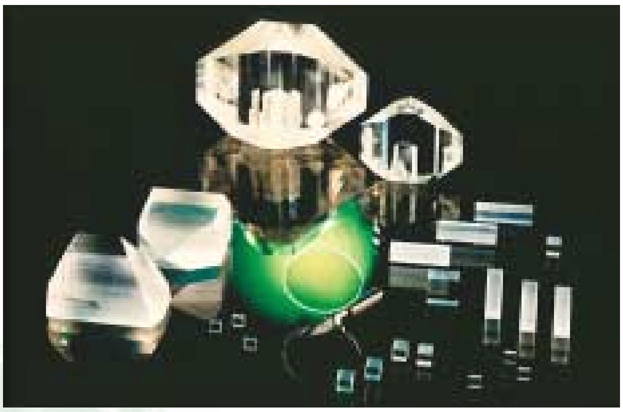
KTA

KTP:fr

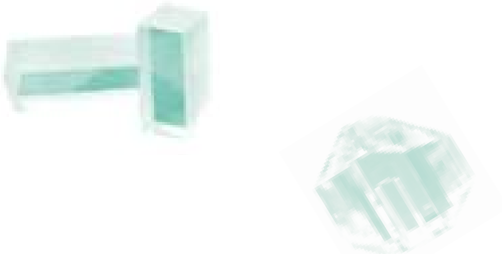
Cristal Laser, a privately owned, independent business located near Nancy, France, is specialized in crystal growth and processing for applications in non-linear and laser optics. The company, founded in 1990 by a team of researchers and engineers, started the production of KTP crystals at an industrial scale thanks to an exclusive licence granted from CNRS, the French Council for Scientific Research ■

A long way has been gone since then. Today, Cristal Laser has become one of the major players in its area of business. In 2004, the company moved into brand new, tailor-made premises with enough space for its staff of 14 technicians and engineers as well as its world class manufacturing equipment. The company is outfitted with more than 50 resistive crystal growing stations, and also state-of-the art cutting, dicing, grinding and polishing machines, allowing for mass production as well as one-piece manufacturing at the best quality standards. A newly acquired automatic cleaning machine enables Cristal Laser to meet the most stringent cleanliness requirements. A whole set of controlling tools, including an X-ray goniometer, interferometers, microscopes and laser measurement benches, ensures that none of the finished crystals is shipped without a thorough and extensive quality check-up ■

Cristal Laser's production range includes KTP (Potassium Titanyle Phosphate) and other crystals of the same family, such as KTA, RTP and RTA, and also LBO. These crystals are widely used in many applications covering areas from laser surgery, to life sciences, security and defence as well as material processing. Over the years the company gained the confidence of a broad customer base, established in America, Europe and the Far East. Thanks to them, the company achieved a steady and sustainable growth pace over the past years, regardless macro-economic factors or market conditions in particular business areas ■



Cristal Laser S.A - Parc d'Activité du Breuil - 32, rue Robert Schumann - F-54850 Messein FRANCE
Phone : +33(0)3 83 47 01 01 - Fax : +33(0)3 83 47 22 72 - www.cristal-laser.fr - mail@cristal-laser.fr



KTP >

Applications

Operation	Advantages	Field of Application
SHG		
• Fundamental range: 1.0-1.3 µm	• Large non-linear coefficient (~3 pm/V at 1064/532 nm) • Small walk-off	• Low-power CW scientific lasers • Surgical lasers (ophtalmology, dermatology) • Ti: Sapphire laser pumping
OPO		
• X-cut Signal wavelength: 1.57 µm • OPO range: 1.53 - 3.0 µm	• Monolithic design available: OPO mirrors on the crystals' faces • High efficiency • Walk-off compensating design available at 2.1 µm	• Eye-safe instruments (target designators, range finders) • ZGP OPO pumping

Optical properties

Average refractive index: 1.8

Coefficients in Sellmeier's equation)

$$\left[n_i^2 = A_i + \frac{B_i}{(\lambda^2 - C_i)} - D_i\lambda^2\right]$$

Index	A	B	C	D
n_x	3.006700	0.039500	0.042510	0.012470
n_y	3.031900	0.041520	0.045860	0.013370
n_z	3.313400	0.056940	0.059410	0.016713

for 0.5 < λ < 3,5 µm — C. Bonnin, Cristal Laser

Temperature coefficients of refractive indices, °C $^{-1}$

$$\left[T = 25°C \text{ and } \beta = \frac{1}{n}\frac{\Delta n}{\Delta T}\right]$$

β_{nx}	3.12 x 10 $^{-6}$
β_{ny}	3.6 x 10 $^{-6}$
β_{nz}	6.24 x 10 $^{-6}$

Transparency range, µm: 0.35 → 4.5

Residual absorption (Photo-thermal Common-path Interferometer): <50 ppm/cm at 1064 nm, <1 %/cm at 514 nm

Physical properties

Chemical formula		$KTiOPO_4$
Crystal structure		Orthorhombic
Point group		mm²
Lattice parameters, Å	a	12.82
	b	6.40
	c	10.59
Hardness (Mohs)		Near 5
Hygroscopic susceptibility		none
Density, g.cm $^{-3}$		3.03
Specific heat, cal.g $^{-1}$.°C $^{-1}$		0.1737
Ionic conductivity (room temperature, 10 kHz), S.cm $^{-1}$		10 $^{-6}$
Aperture, mm²		up to 18 x 18
Length, mm		up to 35

< LBO

Applications

Operation	Advantages	Field of Application
SHG		
• Fundamental range: 0.6-1.3 µm	• Small walk-off	• High-power scientific CW lasers
• THG at 1.06 µm	• No grey-track	• High rep. rate, high average power lasers for material processing
• FHG at 1.32 µm	• Non-critical phase match at T=150°C for SHG @1064 nm	
• UV wavelengths achievable: 0.33-0.35 µm	• Very high bulk damage threshold	• Gas laser replacement

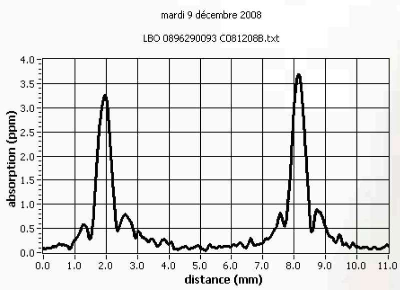
Optical properties

Average refractive index			1.6		
Coefficients in Sellmeier's equation	Index	A	B	C	D
$\left[n_i^2 = A_i + \frac{B_i}{(\lambda^2 - C_i^2)} - D_i\lambda^2 \right]$	n_x	2.4542	0.01125	0.01135	0.01388
	n_y	2.5390	0.01277	0.01189	0.01848
	n_z	2.5865	0.01310	0.01223	0.01861
	K. Kato IEEE J.QE-26, 1173 (1900)				
Transparency range, µm					0.16-2.6

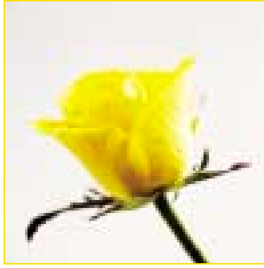
Physical properties

Chemical formula		LiB_3O_5
Crystal structure		Orthorhombic
Point group		mm²
Lattice parameters, Å	a	8.44
	b	7.37
	c	5.14
Hardness, Mohs		5.5
Hygroscopic susceptibility		weak
Density, $g.cm^{-3}$		2.47
Specific heat, J/kg.K		1060
Thermal conductivity, $mW.cm^{-1}.°C^{-1}$		35
Aperture, mm		up to 30 x 30
Length, mm		up to 50

Absorption at 1064 nm of a 8 mm long LBO crystal



- Measured at Cristal Laser with a Photo-Thermal Common Path interferometer from SPTS
- Residual absorption : <10 ppm/cm at 1064 nm, <20 ppm/cm at 532 nm



Applications

Operation and Advantages	Field of Application	Picture of an E-O Q-switch

E-O phase modulation

- Thermally compensated design
- V_π = 1600 V at 1064 nm for a 4x4x10 pair
- No piezoelectric ringing
- Low operating voltages
- Fair damage threshold

Field of Application:

- Q-switches at high rep. rates or where low operating voltages are needed. (e.g. space applications)
- Pulse-picking from a ps or fs pulsetrain

Optical properties

Average refractive index: 1.8

Coefficients in Sellmeier's equation

$$n_i^2(\lambda) = A_i + \frac{B_i}{1-\left(\frac{C_i}{\lambda}\right)^{p_i}} + \frac{D_i}{1-\left(\frac{E_i}{\lambda}\right)^{q_i}}$$

for 0.5 < λ < 3,5 μm

	A_i	B_i	C_i	D_i	E_i	p_i	q_i
n_x	2.1982	0.8995	0.2152	1.5433	11.585	1.9727	1.9505
n_y	2.2804	0.8459	0.2296	1.1009	9.660	1.9696	1.9369
n_z	2.3412	1.0609	0.2646	0.9714	8.149	2.0585	2.0038

Y. Guillien et al., Optical Materials 22 (2003) 155-162

Transparency range, μm		0.35-4.5
Residual absorption (Photo-thermal Common-path Interferometer) : 100 ppm/cm at 1064nm, 1%/cm at 532 nm		
Electro-optical constants (@633 nm, 1 kHz), pm. V^{-1}	r_{33}	33.0
	r_{13}	10.9
	r_{23}	15.0
Dielectric constant (ε_{eff})		13

Physical properties

Chemical formula		$RbTiOPO_4$
Crystal structure		Orthorhombic
Point group		mm²
Lattice parameters, Å	a	12.96
	b	10.56
	c	6.49
Hygroscopic susceptibility		None
Density, $g.cm^{-3}$		3.6
Ionic conductivity (room temperature), $S.cm^{-1}$		10^{-10} to 10^{-9}
Aperture mm^2		up to 9x9
Length mm		up to 10

< BBO

Applications

Operation	Advantages	Field of Application
• THG at 1.06 µm • 4HG at 1.06 µm • 5HG at 1.06 µm	• Fair efficiency • Best commercialy available crystal for 4HG and 5HG	• UV lasers for material processing • Gas laser replacement
• OPO pumped at 532 nm or 355 nm	• Widely tunable • High conversion efficiency	
• E-O phase modulation	• Excellent extinction ratio • Wide transmission range • High damage threshold	• Q-switches at high rep. rates or where high damage threshold is needed

Optical properties

Average refractive index: 1.6

Coefficients in Sellmeier's equation

$$\left[n_i^2 = A_i + \frac{B_i}{(\lambda^2 - C_i^2)} - D_i\lambda^2 \right]$$

Index	A	B	C	D
n_o	2.7359	0.01878	0.01822	0.01354
n_e	2.3753	0.01224	0.01667	0.01516

Negative uniaxial crystal with $n_o > n_e$

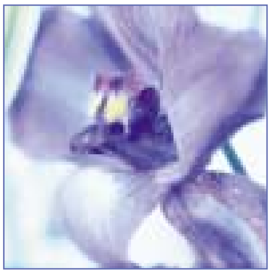
K. Kato IEEE J.QE-22, 1013 (1986)

Transparency range, µm	0.2-2.2
Residual absorption	< 0.1% / cm at 1064 nm

Physical properties

Chemical formula		β-BaB_2O_4
Crystal structure		Trigonal
Point group		3m
Lattice parameters, Å	a	12.53
	b	12.53
	c	12.72
Hardness, Mohs		4
Hygroscopic susceptibility		High
Density, $g.cm^{-3}$		3.85
Specific heat, J/kg.K		490
Thermal conductivity, $mW.cm^{-1}.°C^{-1}$		1.2(⊥c) 1.6(//c)
Aperture, mm^2		up to 13 x 13
Length, mm		up to 20

KTA >



Applications

Operation	Advantages	Field of Application
OPO • X-cut Signal wavelength : 1.54 µm • OPO range : 1.51-3.5 µm	• High efficiency • Small walk-off • High transmission in the 3-3.5 µm range	• Eye-safe instruments (target designators, range finders) with mid-high average powers • Spectroscopy, gas detection

Optical properties

Average refractive index: 1.8

Coefficients in Sellmeier's equation

$$\left[n_i^2 = A_i + \frac{B_i\lambda^2}{(\lambda^2 - C_i^2)} - D_i\lambda^2 \right]$$

for $0.4 < \lambda < 4$ µm

Index	A	B	C	D
n_x	1.90713	1.23522	0.19692	0.01025
n_y	2.15912	1.00099	0.21844	0.01096
n_z	2.14786	1.29559	0.22719	0.01436

Fenimore, Schepler, Ramadabran, McPherson, J. Opt. Soc. Am. B Vol 12(5) 1995

Transparency range, µm	0.35-5.3
Residual absorption (Photo-thermal Common-path Interferometer): 200 ppm/cm at 1064 nm	

Physical properties

Chemical formula		$KTiOAsO_4$
Crystal structure		Orthorhombic
Point group		mm2
Lattice parameters, Å	a	13.12
	b	6.56
	c	10.79
Hardness (Mohs)		5.5
Hygroscopic susceptibility		none
Density, $g.cm^{-3}$		3.45
Ionic conductivity (room temperature, 10 kHz), $S.cm^{-1}$		10^{-6}
Aperture, mm^2		up to 10x10
Length, mm		up to 20

< KTP.fr

Applications

Operation	Advantages	Field of Application
SHG • Fundamental range : 1.0-1.3 µm	• No gray-track • Large non-linear coefficient (~3pm/V at 1064/532 nm) • Small walk-off	• Mid-power CW lasers (up to a few Watts at 532 nm) for scientific or medical applications. • Extracavity SHG of KHz lasers (materials processing)

Optical properties - same as KTP

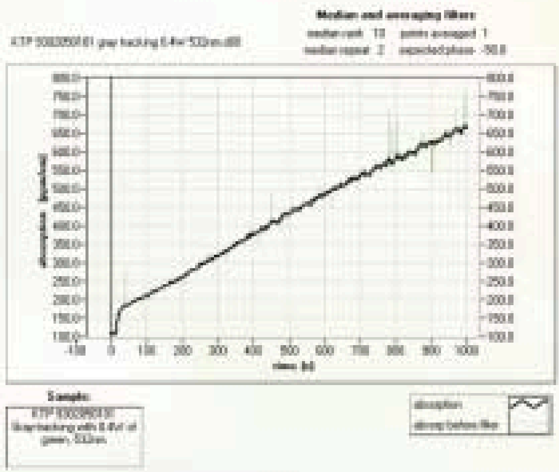
Physical properties

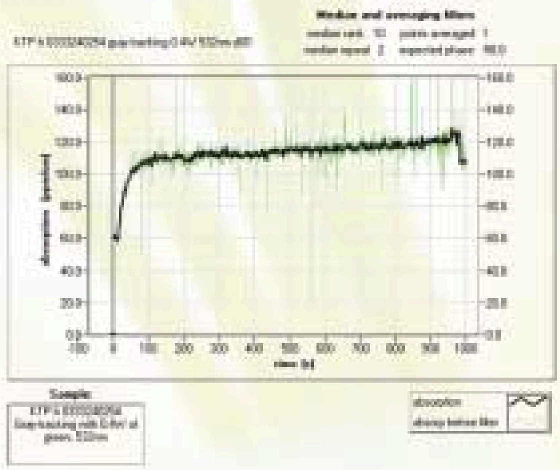
Ionic conductivity, (room temperature), S. cm^{-1}	10^{-11} to 10^{-10}
Aperture, mm^2	up to 10 x 10
Length, mm	up to 10

According to KTP users, gray-track formation can cause harmonic power instability for many intracavity frequency-doubled CW lasers, and reduced conversion efficiency and crystal blackening in case of high power, high repetition rate Q-switched lasers. Sometimes the process is accompanied by beam distortion when the beam is tightly focused in the crystal.

The occurrence of gray-track in a KTP crystal can be measured by an increase of bulk absorption at 1064 nm induced by a strong CW green radiation at 532 nm (10 kW/cm^2). This measurement was performed with the Photo-thermal Common-path Interferometer, a device developed at Stanford University, USA. The two graphs below show the difference between a standard KTP crystal and a grey-track full-resistant KTP.fr crystal, both produced at Cristal Laser.

Whereas the measured absorption sharply and steadily increases in the standard KTP as soon as the green laser is switched on, it rises and then quickly stabilizes in case of the KTP.fr, thus showing gray-track inhibition.





Manufacturing > standards

Facilities / Equipement

Tools

- SECASI X-ray goniometer
- Meyer & Burger slicing machine
- Meyer & Burger dicing machine
- SOMOS grinding machines
- SOMOS polishing machines
- Ultrasonic cleaning machine

Controls

- Binocular and DIC-microscopy
- Interferometers
- Shadowgraph
- Laser test benches for non-linear efficiency check-up
- Laser benches for custom requirements
- Photo-thermal Common-Path Interferometer for absorption measurements

Specifications

Materials processed: laser crystals, glass, and non-linear crystals with typical aperture up to 10 x 10 mm^2 and length up to 30 mm

Aperture cut	tolerance +/-0.1 mm
Length	tolerance +0.3/-0.2 mm
Parallelism	better than 20"
Perpendicularity	better than: 30' (standard), 10' on request
Flatness (λ=633 nm) within a 80 % circular clear aperture	better than $\lambda/10$
Orientation	+/-0.5° (standard), +/-0.1° on request
Roughness	better than 10 Å RMS
Scratch/dig	10-5
Wavefront distortion (λ = 633 nm)	better than $\lambda/4$ for less than 30 mm single pass length

For custom requirements please contact us

Thin film coatings

Technologies available	e-beam, IAD, IBS
Damage threshold	500 MW/cm^2 AR-coated, 10 J/cm^2 at 10 Hz, 10 ns, 200 shots S on 1, beam size at $1/e^2$ 500 µm
AR coatings e.g. for 1064/532 frequency-doublers	better than 0.1% (0.05% on request) at 1064 nm, 0.5% at 532 nm

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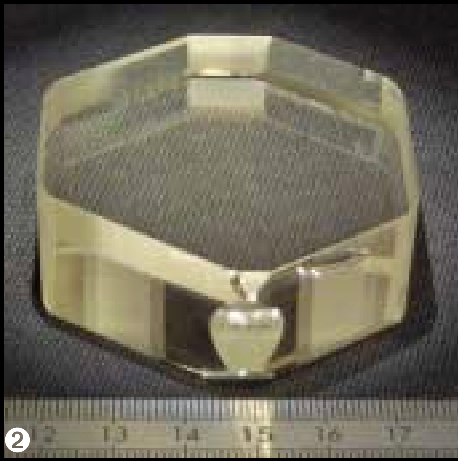

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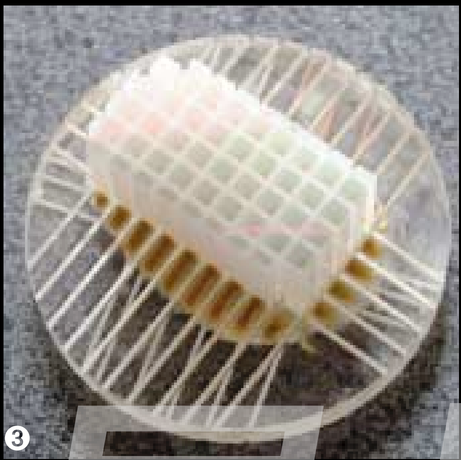

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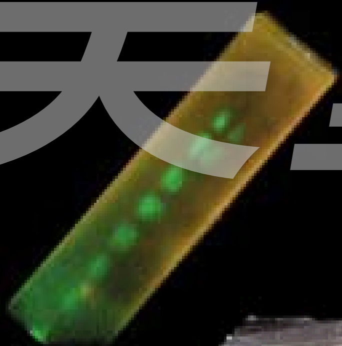

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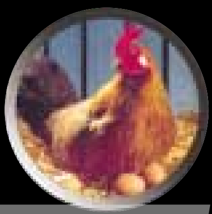
❶ Frequency-doubling KTP 20x20x5 mm crystal with KTP boule
❷ KTP slab from boule pulled along the X-axis
❸ Dicing of coated slabs
❹ SHG crystal slightly out of phase match
❺ Green beam stemming out of SHG crystal
❻ As-grown LBO crystals
❼ Our facility on sunny days
❽ Place Stanislas, Nancy, France

6

CRISTAL LASER

We do

Growth of non-linear crystals



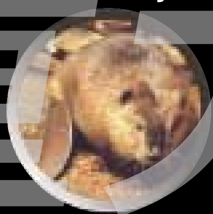
Polishing

Optical controls

We serve

Space & defense

Industry



Healthcare & Science

Because they need

Reliability

Skills

Reaction

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