YCOB crystal for piezoelectric applications

Chemical formula: $YCa_4O(BO_3)_3$ （YCOB）

Introduction: YCOB crystal was first found in 1990s. Because it has good nonlinear optical properties and high temperature piezoelectric properties and it is easy to grow large size crystal with high quality, it attracts attention new in recent years. YCOB crystal has very high electric resistivity that can be fabricated as piezoelectric sensors working at the temperature as high as 1000ºC in aerospace engines. Compared with LGT crystal which is common used in high-temperature vibration sensors, it has following advantages: much higher electric resistivity (three orders higher), and less cost in raw material.

Another application is in the field of high energy and high power laser fields，including second-harmonic generation (SHG), third-harmonic generation (THG), optical parametric oscillator (OPO), optical parametric amplification(OPA),optical parametric chirped-pulse amplification (OPCPA).

Application fields:

- **Piezoelectric sensors at high temperature:** piezoelectric acceleration sensors, pressure sensors, gas sensors, etc.

Table 1. General Specifications of YCOB elements for piezoelectric applicatons

Case	dimension （mm）	Cut orientation	d_{eff} （pC/N）
Shear mode sensors	Blank: 10 x 10 x 0.5	yxt/-30º	d_{26} = 10.0
Compression mode sensors	Wafer: Φ50.8 x 1.0	xylw/-15º/+45º	d_{11} = 6.5
Other	Block: 20 x 20 x 20	XYZ faces	NA

Note: other specs can be fabricated according to customer's requirements

- **Laser wavelength conversion:** second-harmonic generation (SHG), third-harmonic generation (THG), optical parametric oscillator (OPO), optical parametric amplification(OPA),optical parametric chirped-pulse amplification (OPCPA).

Table 2. Chemical and Structural Properties of YCOB Crystal

Crystal Structure	Monoclinic, Point group m
Lattice Parameter	a=8.0770 Å, b=16.0194 Å , c=3.5308 Å , β=101.167º, Z=2
Melting Point	About 1510ºC
Mohs Hardness	6~6.5
Density	3.31 g/cm^3
Thermal Conductivity	2.6 W/m/K (‖X), 2.33 W/m/K (‖Y), 3.1 W/m/K (‖Z)
Thermal Expansion Coefficient	a_x=10.8x10^{-5}/K, a_y= -8.8x10^{-5}/K, a_z=3.4x10^{-5}/K

Table 3.Dielectric and Elastic Properties of YCOB compared with LGT

Properties	YCOB	LGT
Piezoelectric Constants (pC/N)	d_{11} = 1.7 ; d_{12} = 3.9 ; d_{13} = -4.2 ; d_{15} = -1.1 ; d_{24} = 4.4 ; d_{26} = 7.9 ;d_{31} = -0.77 ; d_{32} = -2.5; d_{33} = 1.4 ; d_{35} = -5.0 ;	d_{11} = 7.4; d_{14} = 2.8 ;
Dielectric Constants	$\varepsilon_{11}^T/\varepsilon_0$ = 9.65; $\varepsilon_{13}^T/\varepsilon_0$ = 0.95; $\varepsilon_{22}^T/\varepsilon_0$ = 11.8; $\varepsilon_{33}^T/\varepsilon_0$ = 9.55;	$\varepsilon_{11}^T/\varepsilon_0$ = 19.9; $\varepsilon_{33}^T/\varepsilon_0$ = 77.2;
Elastic Compliance Coefficient (10^{-11} m^2/ N)	S_{11} = 0.72; S_{12} = -0.08; S_{13} = -0.247; S_{15} = 0.04; S_{22}= 0.7; S_{23} = 0.055; S_{25} = 0.054;S_{33} = 0.89; S_{35} = -0.012; S_{44} =3.45; S_{46} = -0.037; S_{55} = 2.10; S_{66} = 1.63	S_{11} = 0.905; S_{12} = -0.449; S_{13} = -0.175; S_{14} = -0.358; S_{33} = 0.517; S_{44} = 2.151; S_{66} = 2.708
Frequency constants (Hz-m)	N_T = 437 (Thickness mode); N_L = 2208 (Longitudinal mode)	N_T = 1320 (Thickness mode); N_L = 2870 (Longitudinal mode)
Maximum d_{11} and d_{26} corresponding cut orientation	d_{33} = 6.5 pC/N, xylw/-15º/+45º orientation; d_{26} = 9.0 pC/N, yxt/-30º orientation	d_{11} = 7.4 pC/N, X-cut orientation; d_{26} = 14.8 pC/N, yxl orientation
Piezo constant temperature coefficient (10^{-6} /ºC)	5500 (d_{26})	1336 (d_{11})
Pyroelectric effect	Yes	No

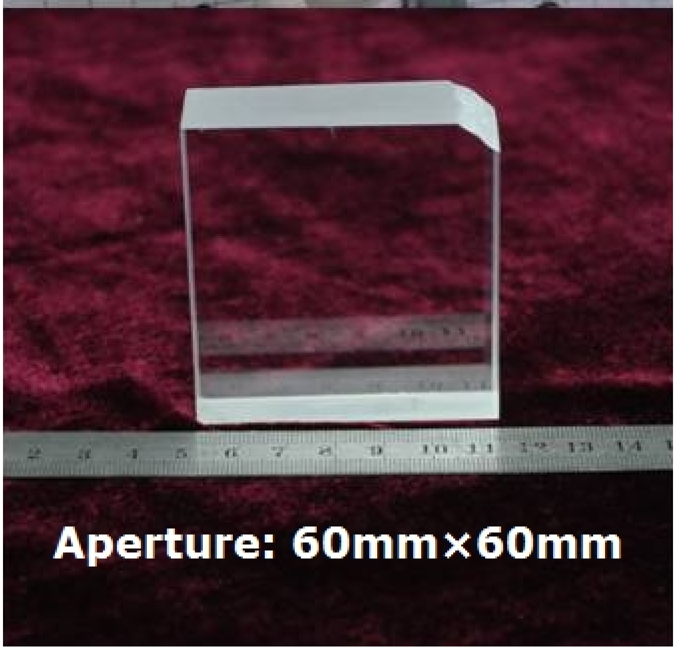
Table 4. Electric Resistivity Properties (Ω·cm) of YCOB compared with LGT

Electric Resistivity	YCOB	LGT
540ºC	2.0×10^{10}	2.0×10^{7}
650 ºC	3.0×10^{9}	1.0×10^{6}
1000 ºC	1.0×10^{7}	NA

Warranty on YCOB Specifications:

* Dimension tolerance: (W±0.1mm)x(H±0.1mm)x(L+0.5/-0.1mm) (L≥2.5mm)
  (W±0.1mm)x(H±0.1mm)x(L+0.1/-0.1mm) (L<2.5mm)
* No visible scattering paths or centers when inspected by a 20mW green laser
* Chamfer: ≤0.2mmx45°
* Chip: ≤0.1mm
* Parallelism: better than 60 arc seconds
* Perpendicularity: ≤10 arc minutes
* Angle tolerance:≤0.5°


3'' YCOB Crystal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