



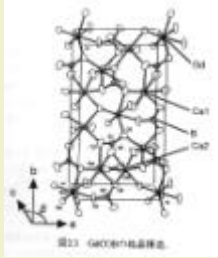
Measurement of Material Constants and Theoretical Calculation of SAW Characteristics of GdCOB Crystals

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New Material: $GdCa_4O(BO_3)_3$ (GdCOB)

Gadolinium Calcium Oxoborates

Symmetry	Monoclinic
	Cm
	$= 90[^\circ]$
lattice constant	$= 101.27[^\circ]$
	$a=8.094[]$
	$b=16.013[]$
	$c=3.558[]$

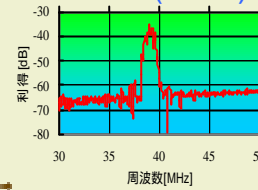


Grown Seed	Cz
Grown direction	$YCa_4O(BO_3)_3$
Temperature	b axis
Rotation	1480 []
Pulling speed	20[mm]
Atmosphere	2.0[mm/h]
	Ar

Sasaki et al: Laser Eng., 27 (1999) 519-524

Feature

Chemical stability, Low cost, Hardness (~Quartz)
 High nonlinear optical coefficient
 SHG, THG (THG for Nd:YAG laser)
 Good piezoelectric (SAW) properties?



SAW properties.
 $k^2: \sim 1\%$
 $v: \sim 4000\text{m/s}$

SAW Theoretical Calculation

SAW characteristics were calculated by computer simulation, and compared with results measured.

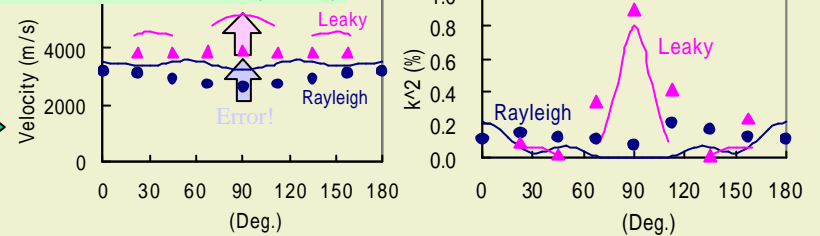
Methods

- Calculation: J. Campbell and W. Jones: IEEE Su-15 (1968) p. 209
- Material Const. (): J. Wang et al: J. Mater. Res. 16 (2001) p.790

Elastic compliance $s(10^{-12} \text{m}^2/\text{N})$												
s11	s12	s13	s15	s22	s23	s25	s33	s35	s44	s46	s55	s66
7.7	0.44	0.13	0.04	7.3	-1.9	1.6	8.9	-1.1	13.6	10	18.1	15
Piezoelectric constants $d(10^{-12} \text{C/N})$												
d11	d12	d13	d15	d24	d26	d31	d32	d33	d35			
-2.4	-3.8	4.3	2.4	2.9	3.5	-2.6	-4.5	2.6	5.7			
Dielectric const.				Density (g/cm ³)								
11	13	22	33									
11.1	0.97	15	12.1									

There are invalid values, such as $s_{12} > 0$, $d_{11} > 0 \dots$

Results calculated (Z cut)



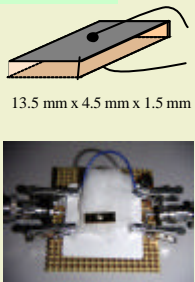
Velocity calculated was higher than that of measured because of errors of Material (Elastic) constants

Material constants of GdCOB are required to be measured accurately.

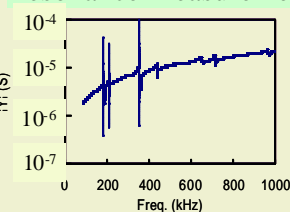
Measurement of Material Constants

Resonance-antiresonance method Elastic s and piezoelectric d constants

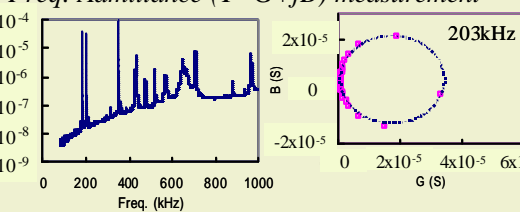
Resonator



Resonance measurement



Freq.-Admittance ($Y=G+jB$) measurement

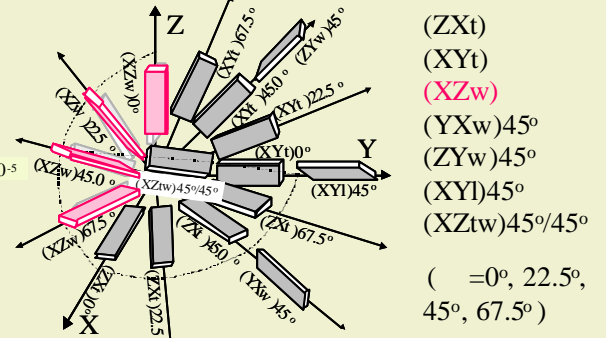


Resonance (f_r) and antiresonance (f_a) frequency constants

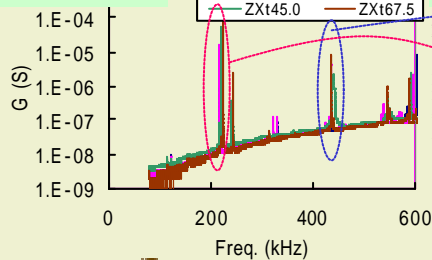
$$f_r = \frac{1}{2L\sqrt{s^E r}} \quad k^2 = \frac{d^2}{2f_a} \tan \frac{p(f_a - f_r)}{2f_a} = \frac{d^2}{s^E e^T}$$

s^E : Elastic, d : Piezoelectric const.
 L : Length
 ρ : Density, T : Dielectric const.

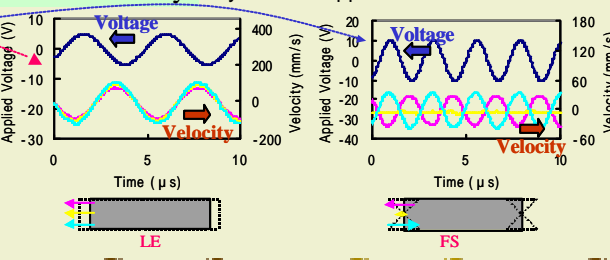
Cuts Modified from method of monolithic 2 by Mason



Resonance



Mode Identify by Laser doppler observation



New material constants

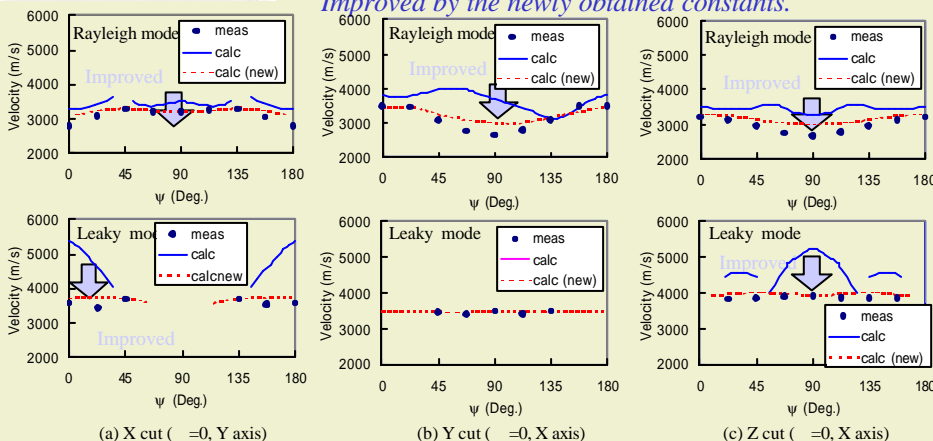
	s11	s12	s13	s15	s22	s23	s25
Wang	7.7	0.44	0.13	0.04	7.3	-1.9	1.6
New	7.60	-1.17	-3.90	-0.40	7.15	-4.62	-1.53
	s33	s35	s44	s46	s55	s66	
Wang	8.9	-1.1	13.6	10	18.1	15	
New	8.94	0.32	27.9	1.68	22.8	17.8	

$s_{12}, 13, 23$: Change to negative value
 $s_{44}, 55, 66$: Increase decrease SAW velocity

SAW calculation

SAW calculations were performed using old/new constants.

Improved by the newly obtained constants.



Summary

Material constants of GdCOB were measured, and SAW calculations using them were performed.

- From the comparison with resonance frequencies of various cuts and laser doppler observation, vibration modes were confirmed.
- Elastic const. ($s_{11}, s_{12}, s_{13}, s_{15}, s_{22}, s_{23}, s_{25}, s_{33}, s_{35}, s_{44}, s_{46}, s_{55}, s_{66}$) can be measured, and s_{44}, s_{55} and s_{66} were higher than old constants.
- SAW calculation results were improved by newly obtained constants. (errors < 12%)

Acknowledgement

