DETECTION DES MACLES DANS LE YAB = $YAl_3(BO_3)_4$

PAR MESURE DU POUVOIR ROTATOIRE

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Twins in YAB

Outline:

Why YAB?

NLO crystals for UV

Issues with twins (scattering, multiple beams)

Twinned crystals

Appearance and properties

Detection based on optical rotation

Outlook: other interesting properties of YAB

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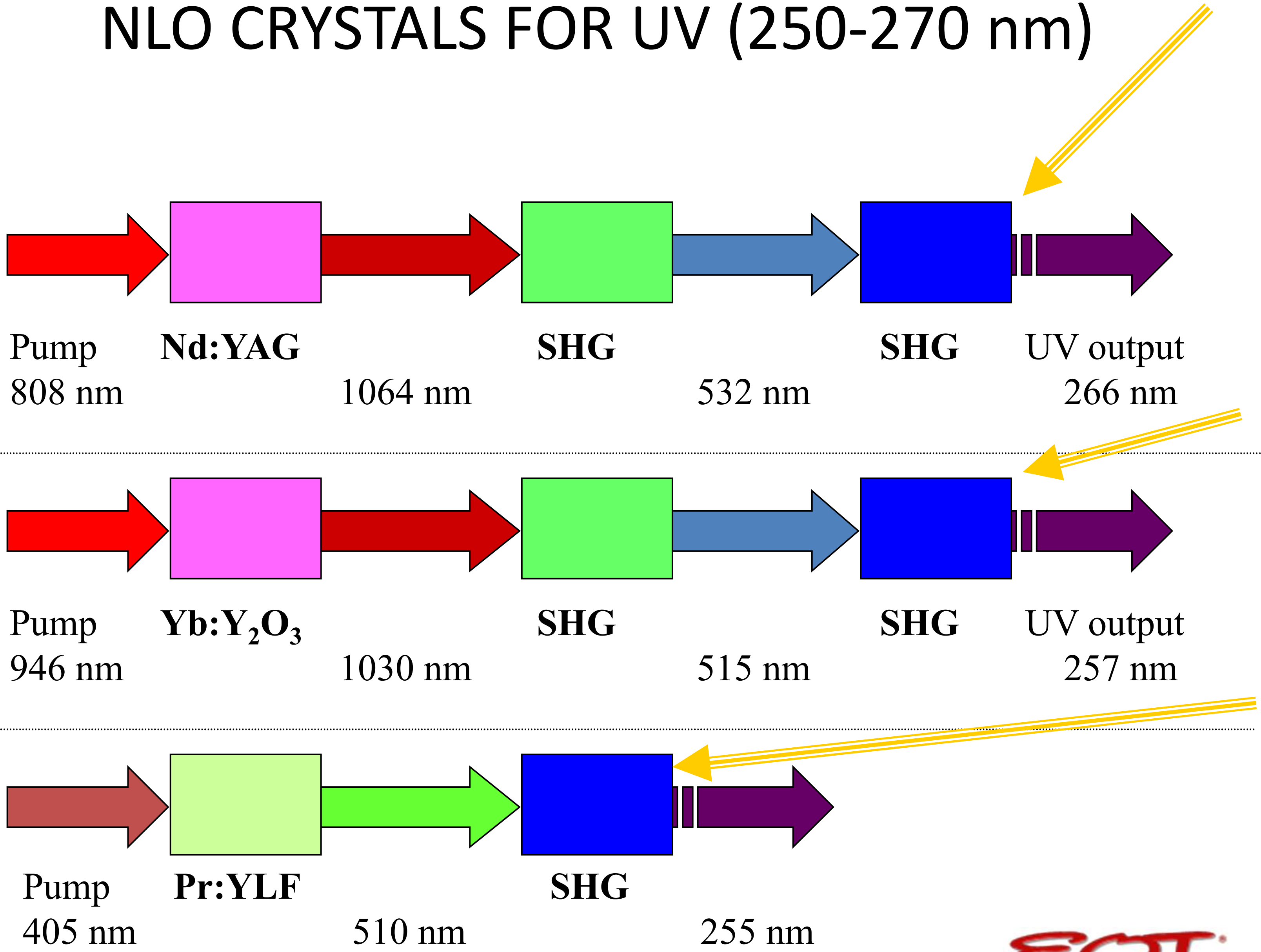
NLO CRYSTALS FOR UV (250-270 nm)



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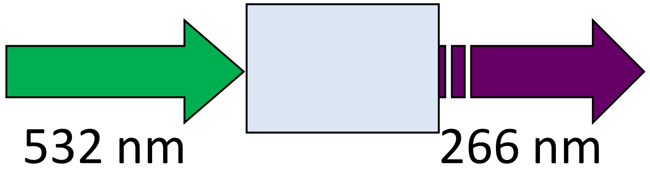
MATERIALS FOR SHG 266 nm



	Type I phase matching angle (°)	d_{eff} (pm/V)	Angular acceptance (mrad cm)	Temperature-acceptance (°C cm)	Walk-off (°)
BBO **BaB_2O_4**	47.5	1.1	0.17	5	4.8
CLBO **$CsLiB_6O_{10}$**	61.5	0.8	0.49	6.2	1.9
LTB **$Li_2B_4O_7$**	66,5	0,16	0,49	> 21	1,6
YAB **$YAl_3(BO_3)_4$**	66.2	0.69	0.41	6	1.9

Advantages of YAB:

- Mechanical stability
- Hardness
- High damage threshold

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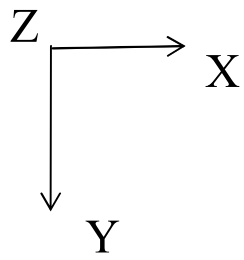
Twins in YAB crystals: scattering effects

In collaboration with A. Maillard, Univ. of Metz (France), Jan. 2011



Laser beam (at 532 nm) propagates along z axis.

Strong scattering observed along all three X = a directions.

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Angular acceptance in YAB crystals

Comparison between twinned and twin-free volume

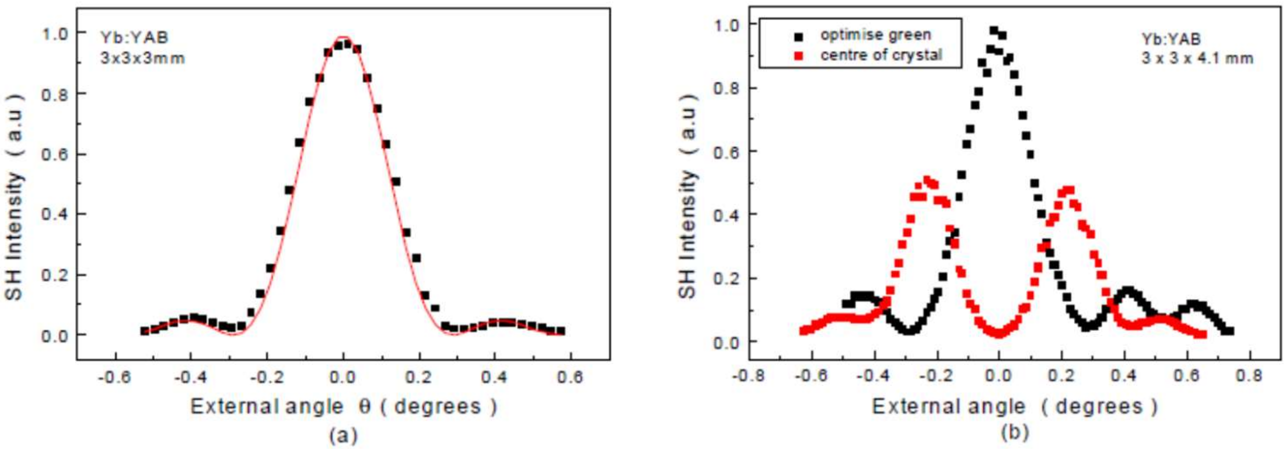

Fig. 2. Angular acceptance curves for phase matched Yb:YAB in crystals without (a) and with (b) twinning. In both cases ϕ was orientated normal to the probe beam.

P. Decker and J.M. Dawes, „Characterization of nonlinear conversion and crystal quality in Nd- and Yb-doped YAB“, Optics Express, 5922, ***12*** *(2004).*

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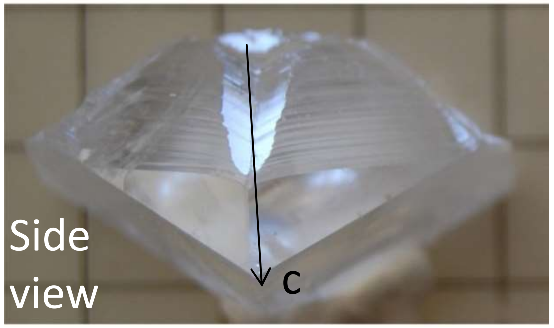
YAB growth
TSSG with Li_2WO_4 flux

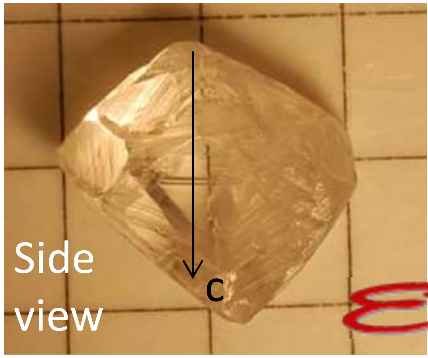
L22-1, weight = 22.7 g

C303-2, weight = 9.2 g

30 mm

20 mm





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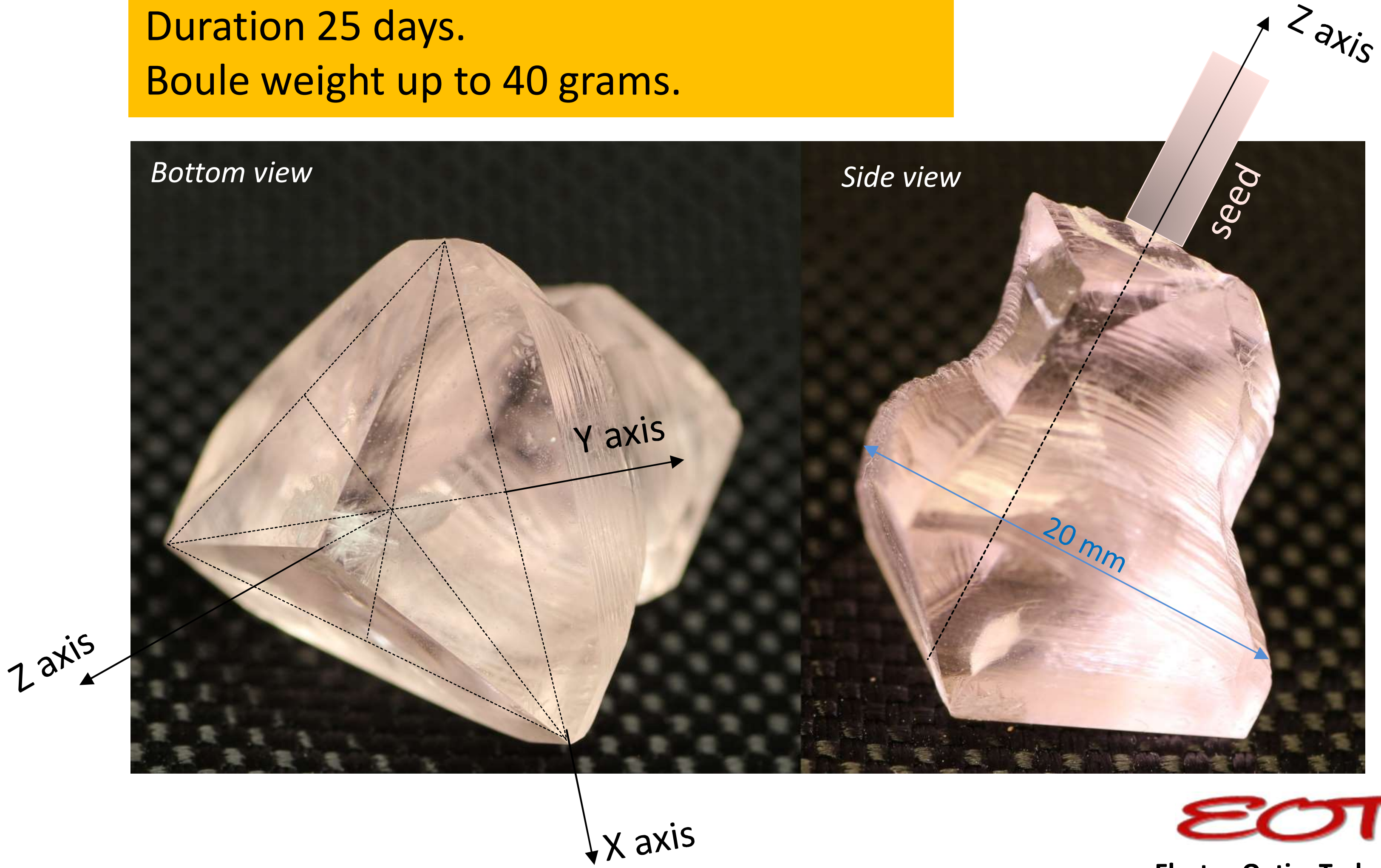
YAB = $YAl_3(BO_3)_4$ grown by TSSG

Li_2WO_4 flux, 70 ml platinum crucible, in air.
Cooling range 25°C.
Duration 25 days.
Boule weight up to 40 grams.



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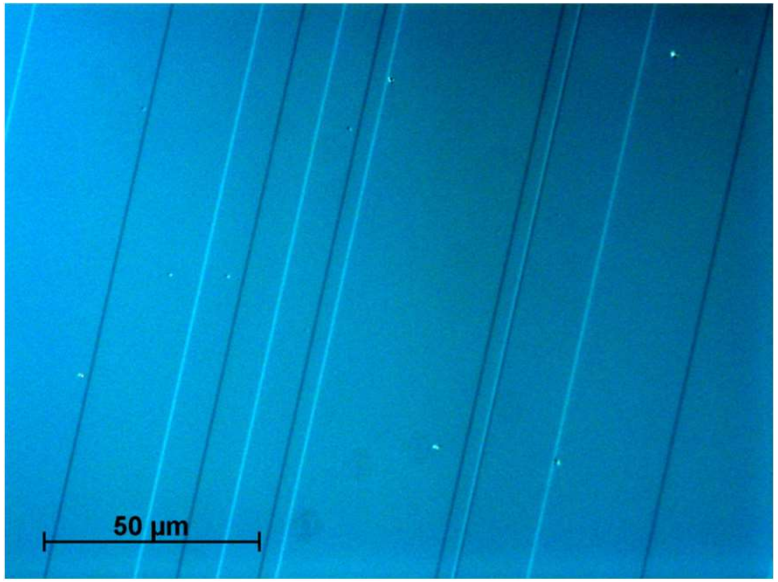
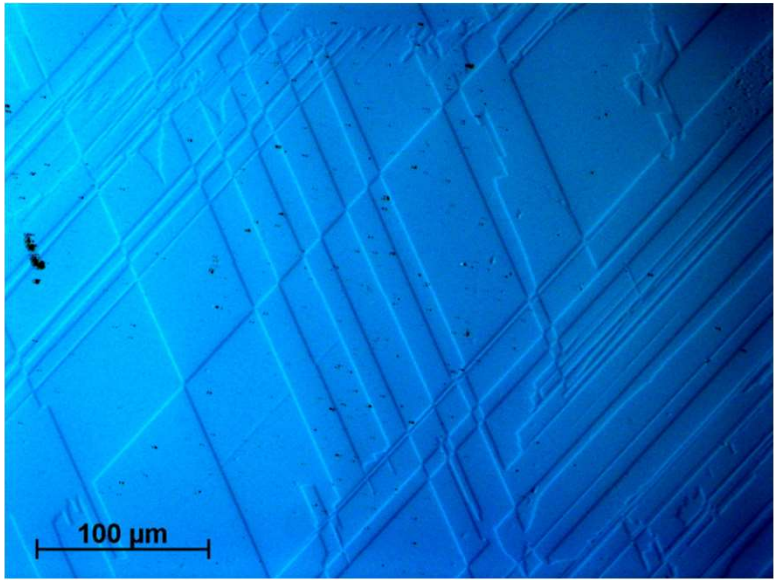
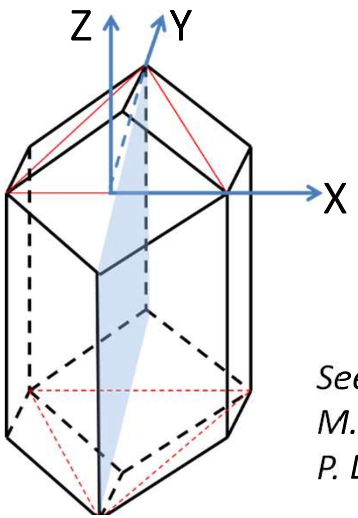
„Microstructures“ observed in YAB crystals

C-DIC = Circular Polarized Light Differential Interference Contrast Microscopy.







Both samples observed along X.

Typical width of lamellas between 5 and 200 µm.

Angle between lamellas is 109°.

See also:
M. Bourezzou, A. Maillard et al., Opt. Mat. Exp. 1 (2011) 1570 .
P. Dekker and J. Dawes, Appl. Phys. B 83 (2006) 267.

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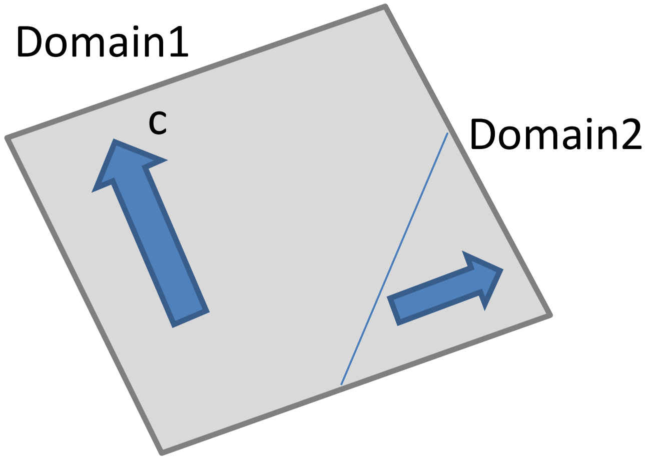
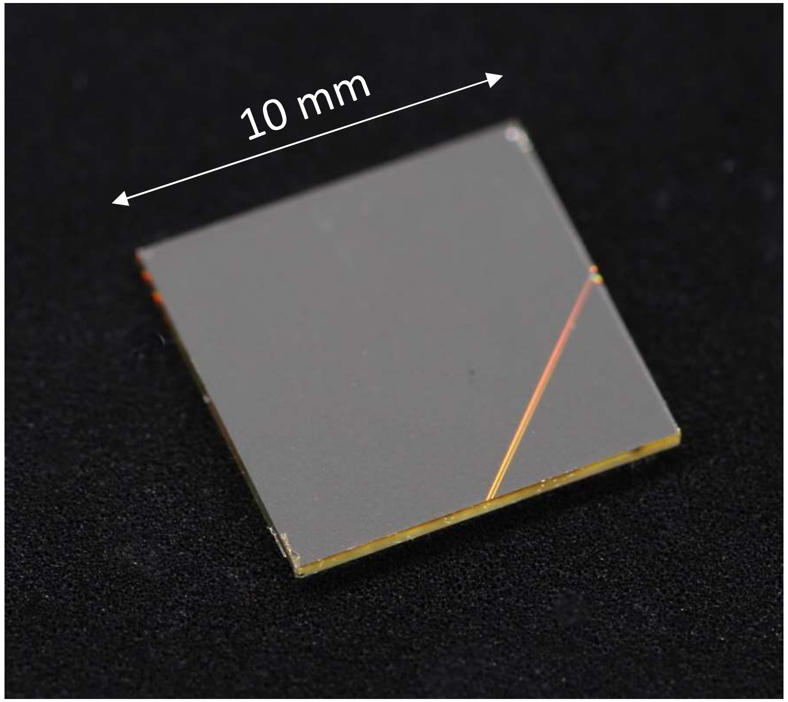
Twins in other crystals

Example: $BaTiO_3$
at 22 °C

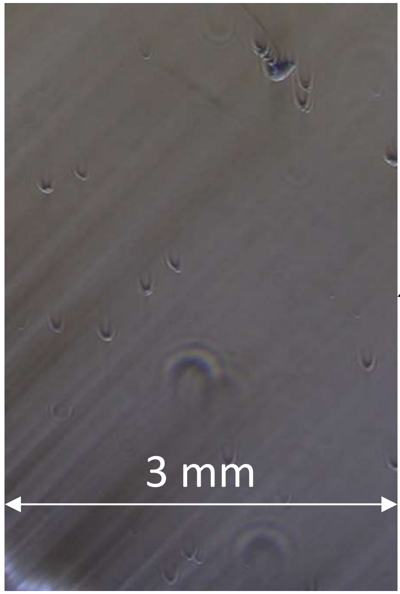




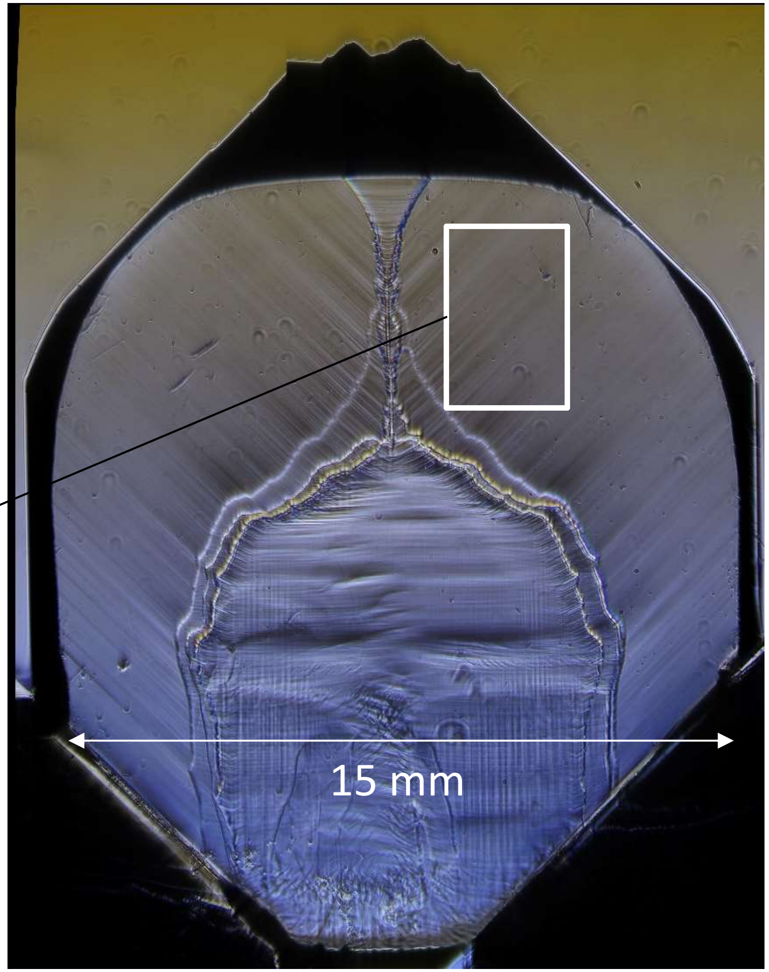
Other type of microstructures

Example: $KTaO_3$

(Shadograph)



Growth striae, reflecting positions of growth interface.



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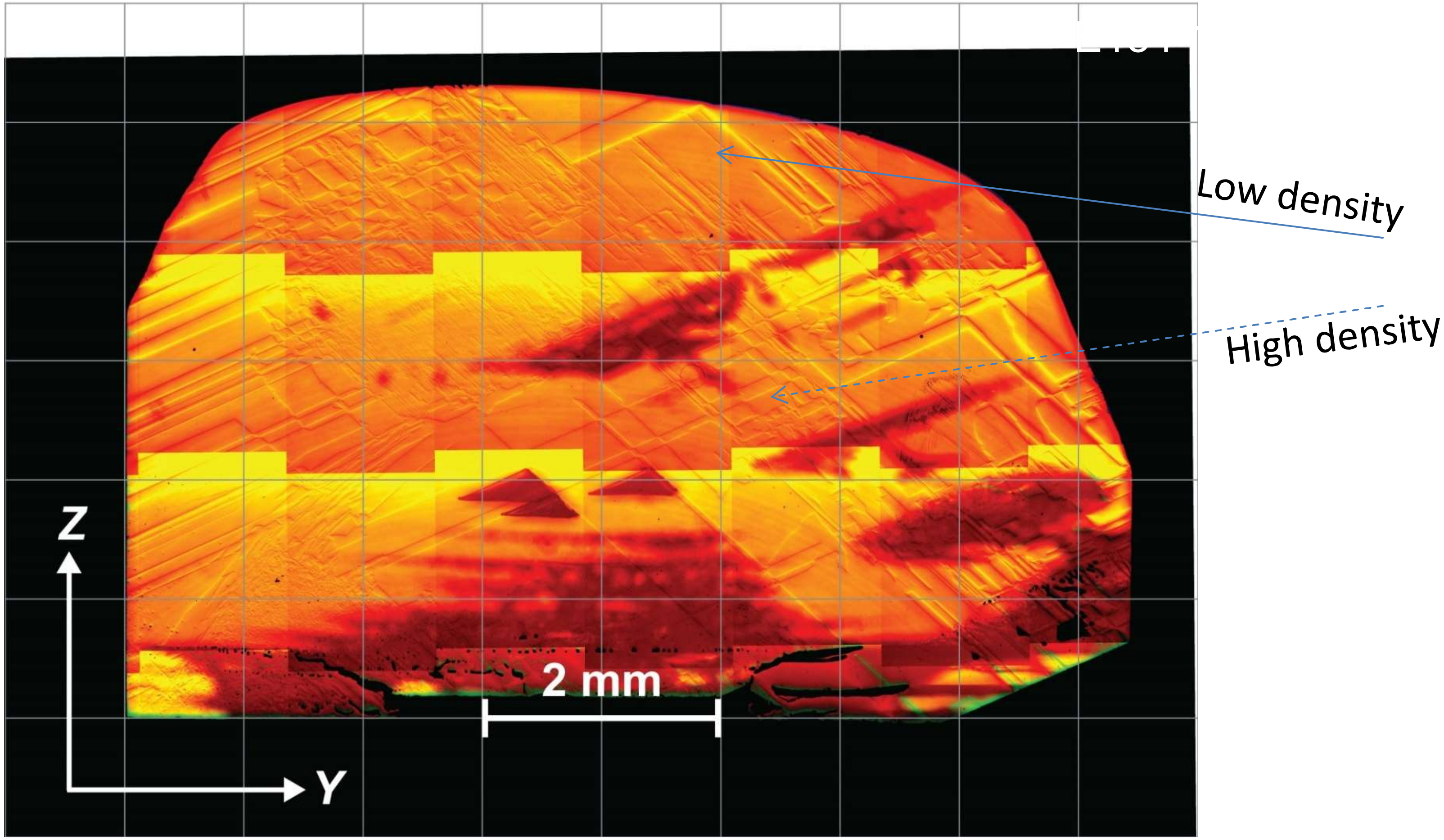
C-DIC micrograph of YAB plate



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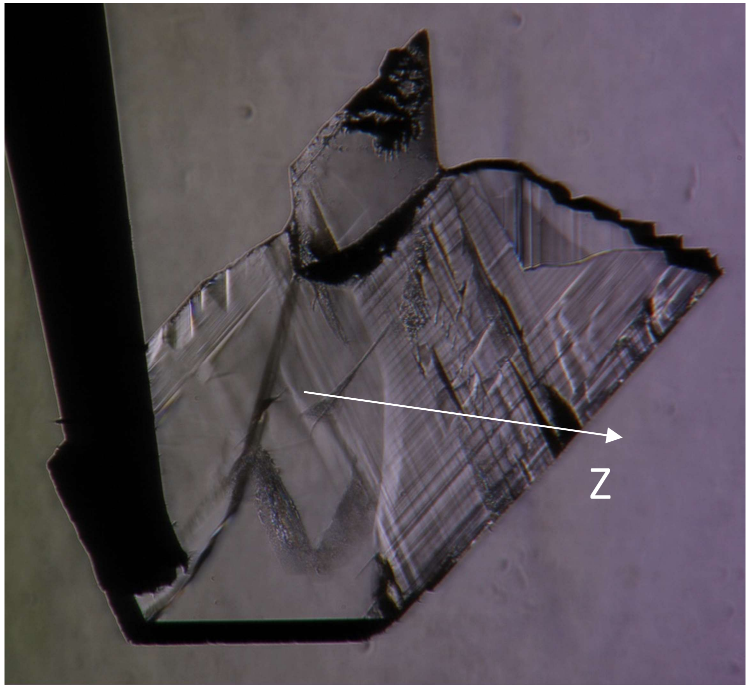
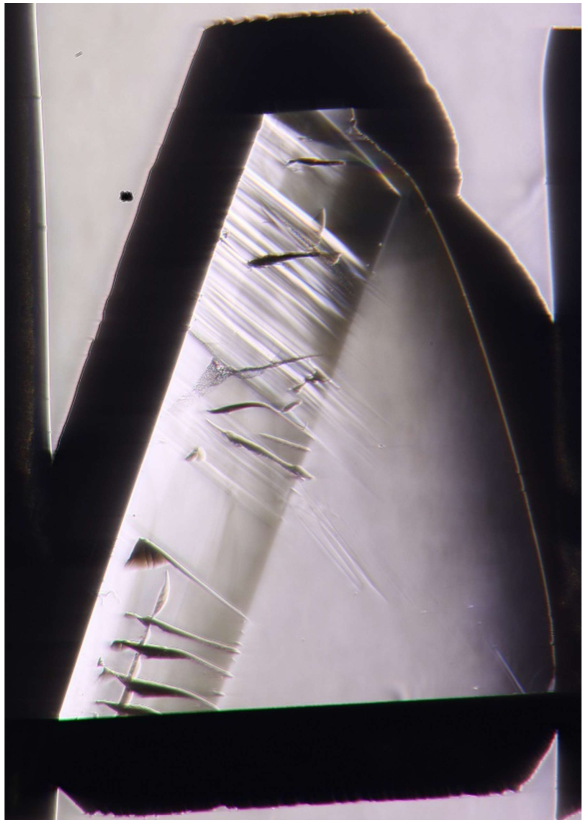
Twins in YAB crystals

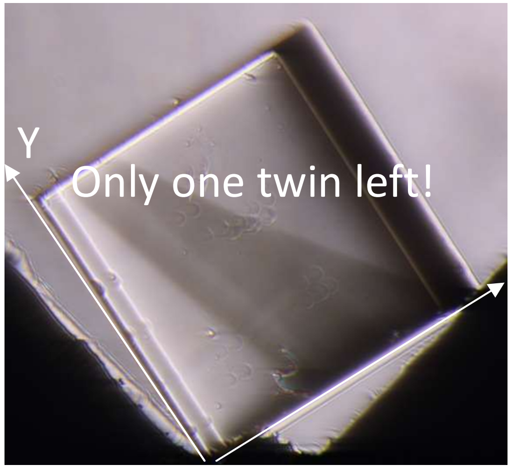
TB 0194 (02)



TB 0195(03)



TI 0184(01)



Axis:
$(90°-\Theta_{PM})X \rightarrow Z$

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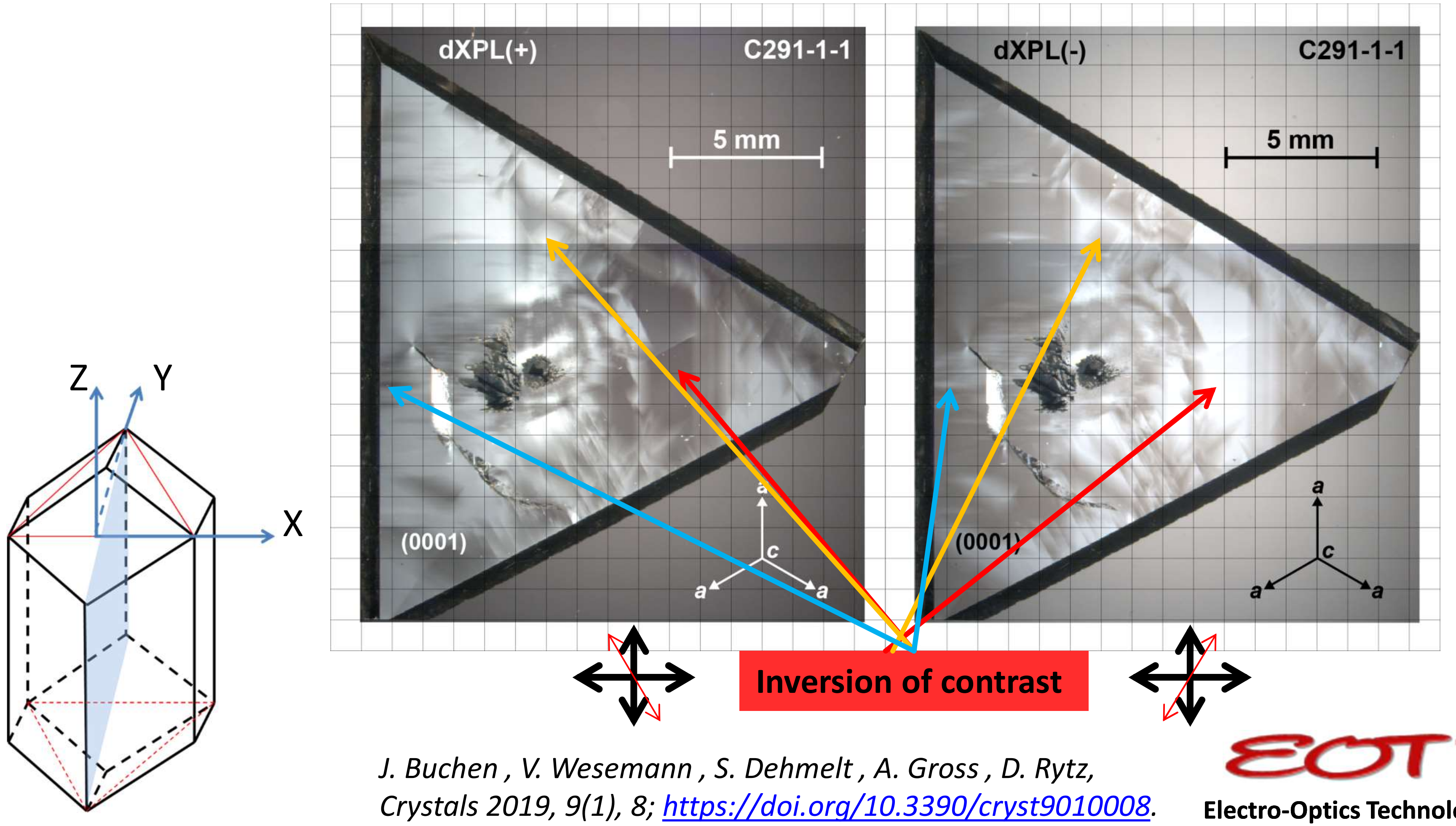
Twins in YAB crystals

revealed by changes in optical activity

Sample viewed along Z axis between slightly misadjusted crossed polarizers



J. Buchen , V. Wesemann , S. Dehmelt , A. Gross , D. Rytz,
Crystals 2019, 9(1), 8; https://doi.org/10.3390/cryst9010008.

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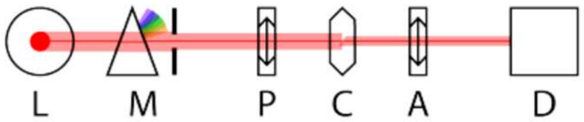
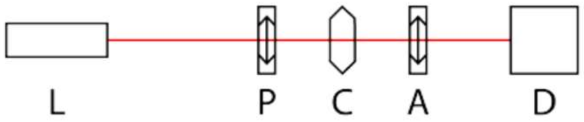
Measurement of optical rotatory power

In spectrophotometer:

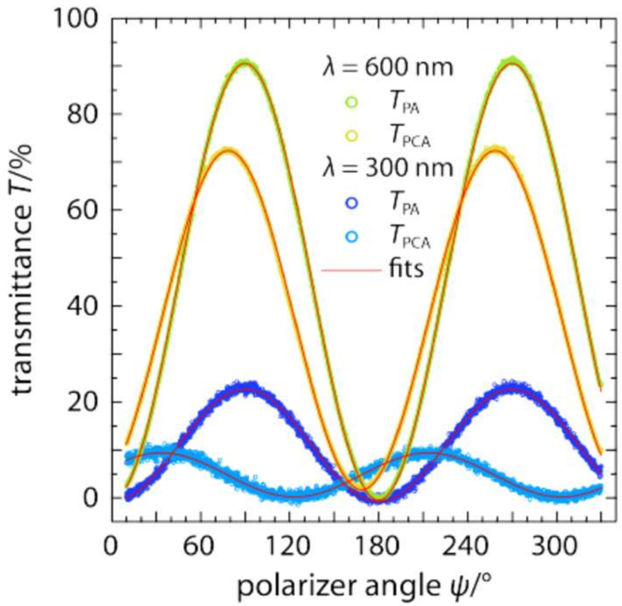


With laser source:



L: light source
M: monochromator
P: rotatable polarizer
C: crystal
A: rotatable analyzer:
D: detector

Transmittance as a function of pol. angle

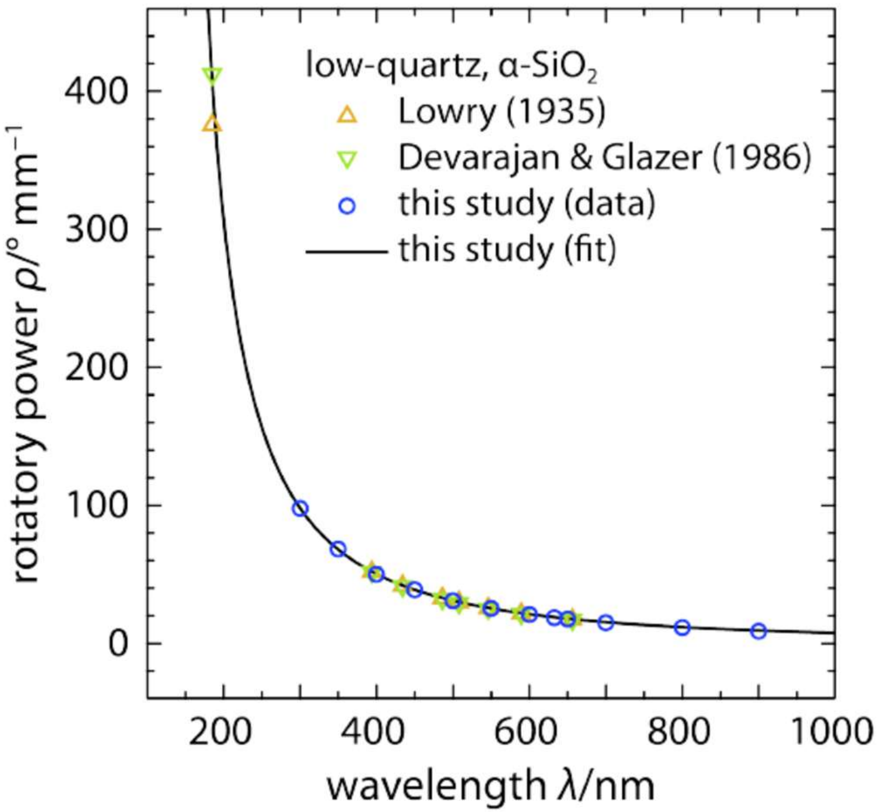


PA: measured through polarizer and analyzer

PCA: through polarizer, crystal and analyzer

Crystals 2019, 9, 8; doi:10.3390/cryst9010008

Optical rotatory power in α-quartz



T.M. Lowry, Optical Rotatory Power, Longmans, London, UK, 1935.
V. Devarajan and A.M. Glazer, Acta Cryst. A 42 (1986) 560.

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Optical rotation angles in YAB („single domain“ case)

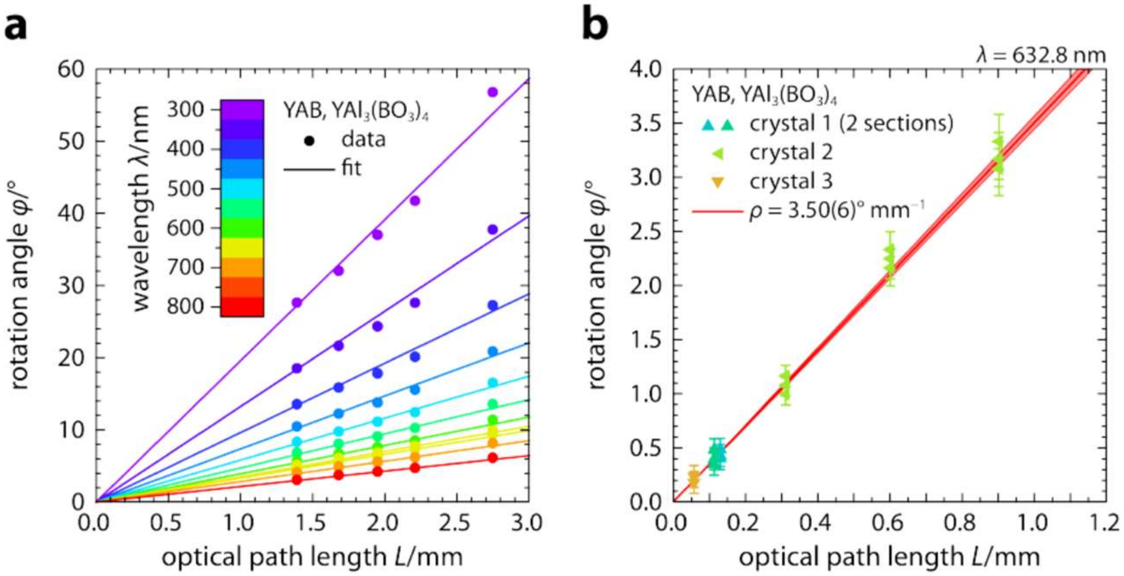
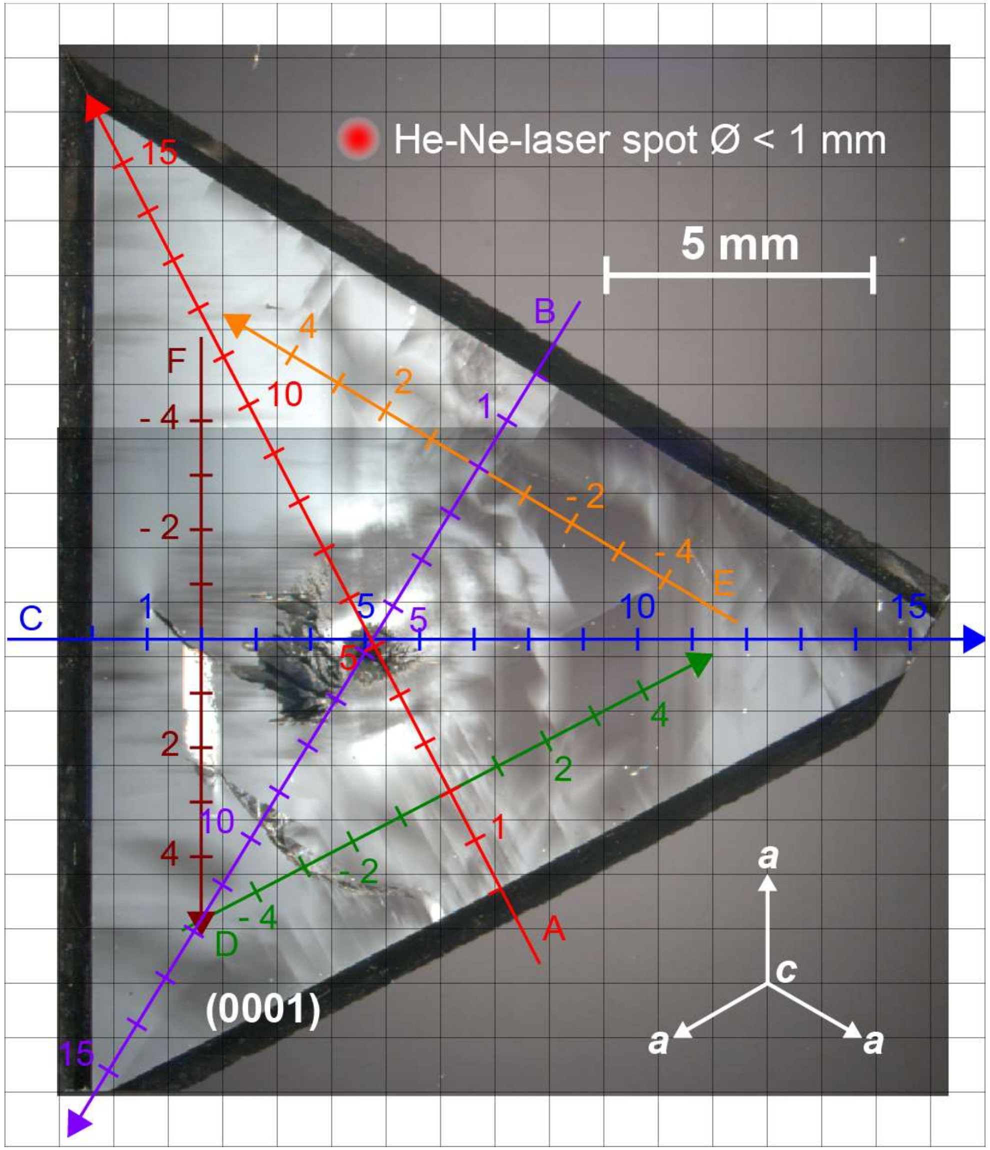


Figure 3. Optical rotation angles of YAB measured on domains with different optical path lengths. In (**a**), the lines show the result of simultaneously fitting a dispersion relation to the observed rotation angles at all wavelengths and path lengths shown in (**a**). The red line in (**b**) shows the fitting result of (**a**) for a wavelength of 632.8 nm. The shading indicates propagated uncertainties on fitted parameters. Note the linear relation between observed rotation angles and path lengths in (**a**) and the agreement of the fit with measurements at 632.8 nm on very thin domains in (**b**).

Optical rotation angles in YAB (multiple domains)



J. Buchen, Thesis
(FEE–U. Mainz, 2013)

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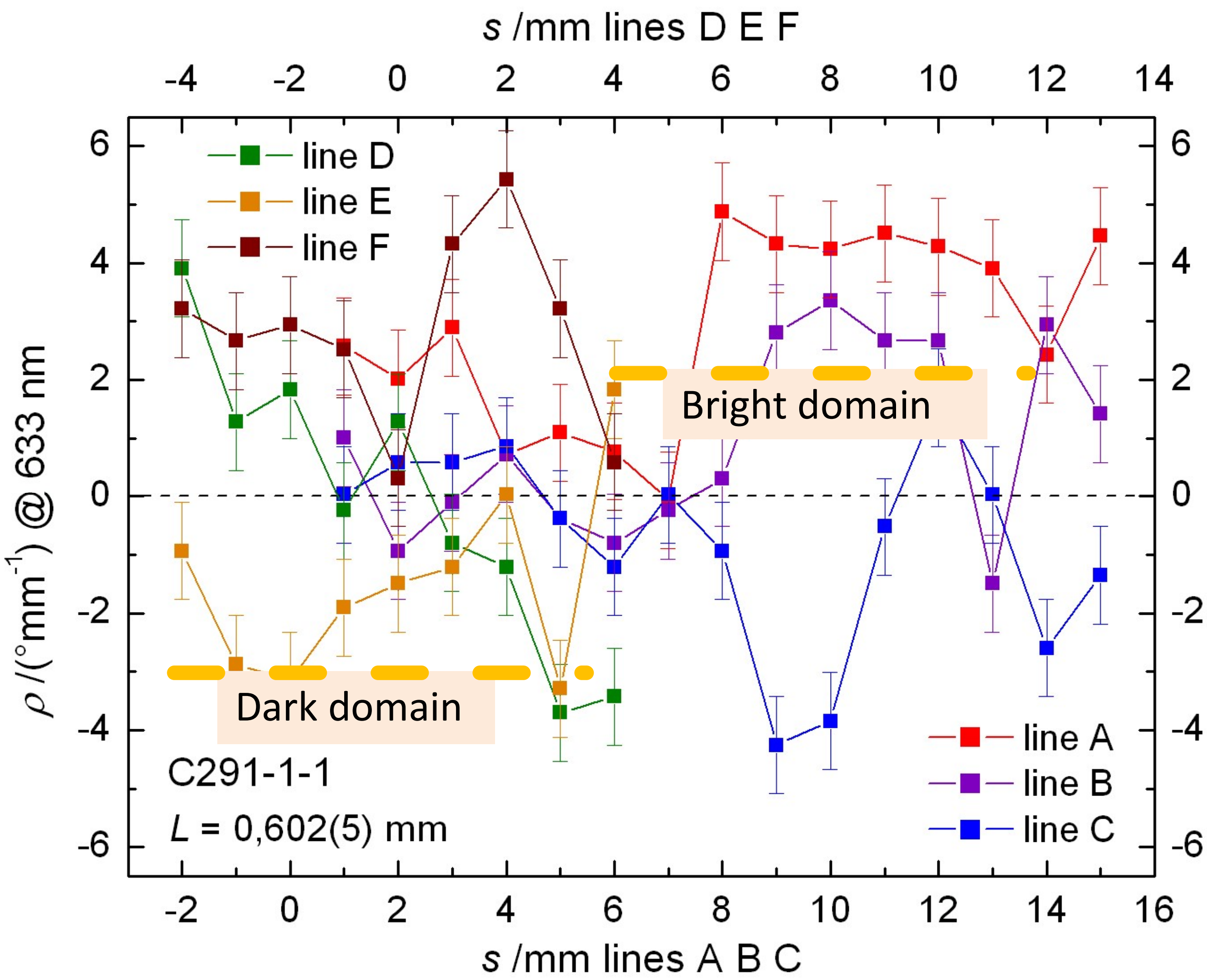
Optical rotation angles in YAB (multiple domains)



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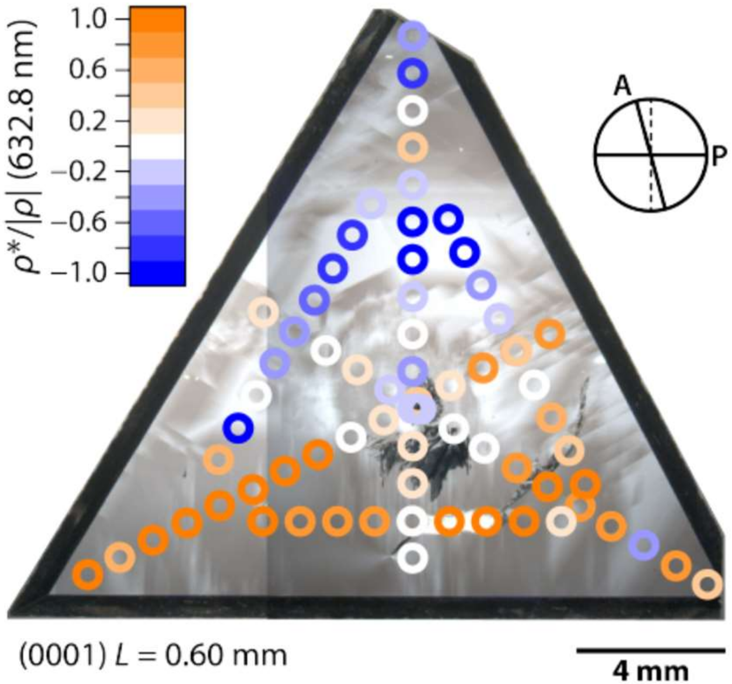
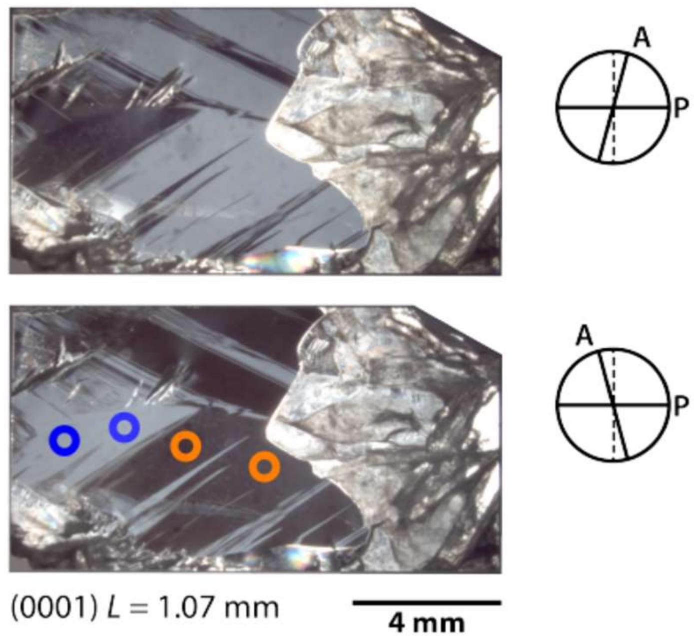
J. Buchen, Thesis (FEE–U. Mainz, 2013)

Complete sign change of optical rotation in YAB (and KABO)

YAB = $YAl_3(BO_3)_4$



KABO = $K_2Al_2B_2O_7$



Images obtained with slightly decrossed polarizers, with two different positions at approx. 90°.
Note congruence between dark (extincted) and bright domains.
Rings indicate position for measurement (laser beam).
Color of rings change with sign of rotatory power.

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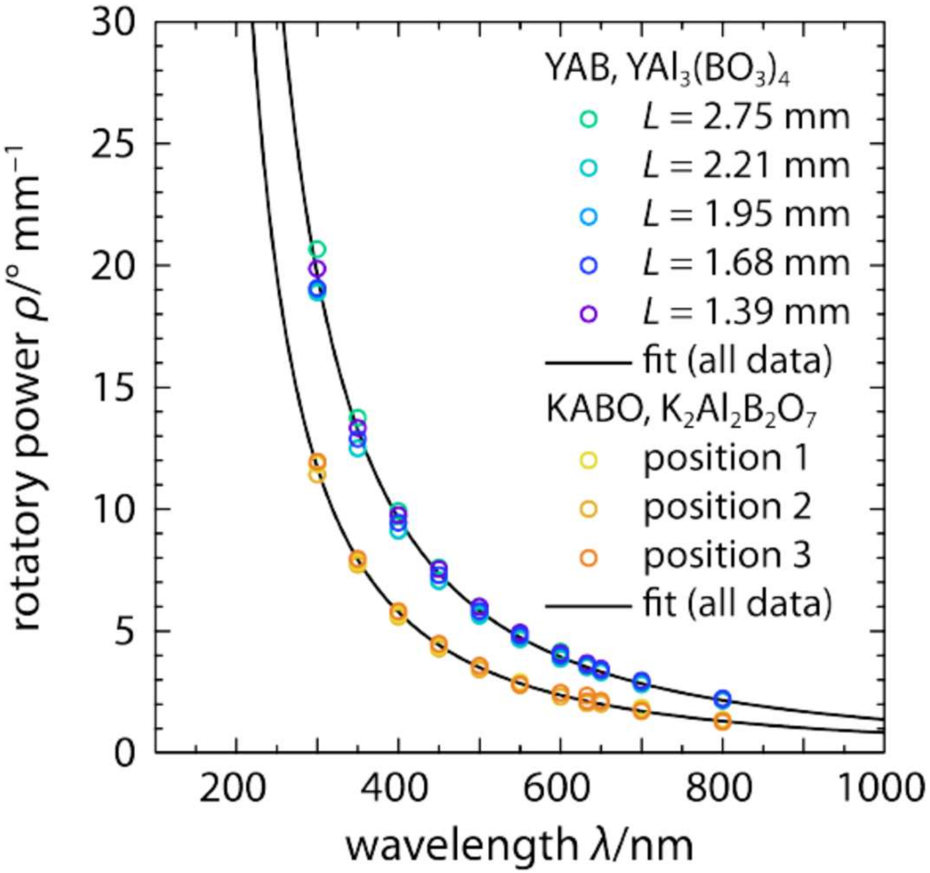
Optical rotatory power for different wavelengths



	266 nm	532 nm	633 nm
YAB	29-30 °/mm	5 °/mm	3,5 °/mm
KABO		3 °/mm	2,1 °/mm

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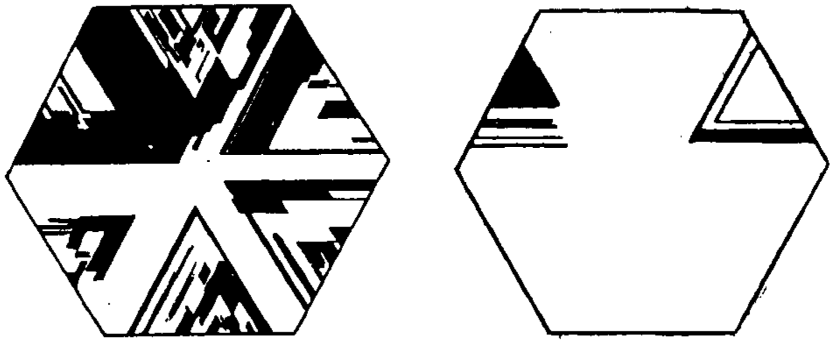
Optical rotatory power: a comparison

Crystal	Dispersion Relation [a]		
	A (° mm)	λ_1 (nm)	ρ^{b}_{633} (° mm^{-1})
Low-quartz, α-SiO_2	7.17(3)	129(1)	18.69(9)
YAB, $YAl_3(BO_3)_4$	1.32(2)	149(4)	3.50(6)
KABO, $K_2Al_2B_2O_7$	0.80(1)	148(3)	2.10(3)

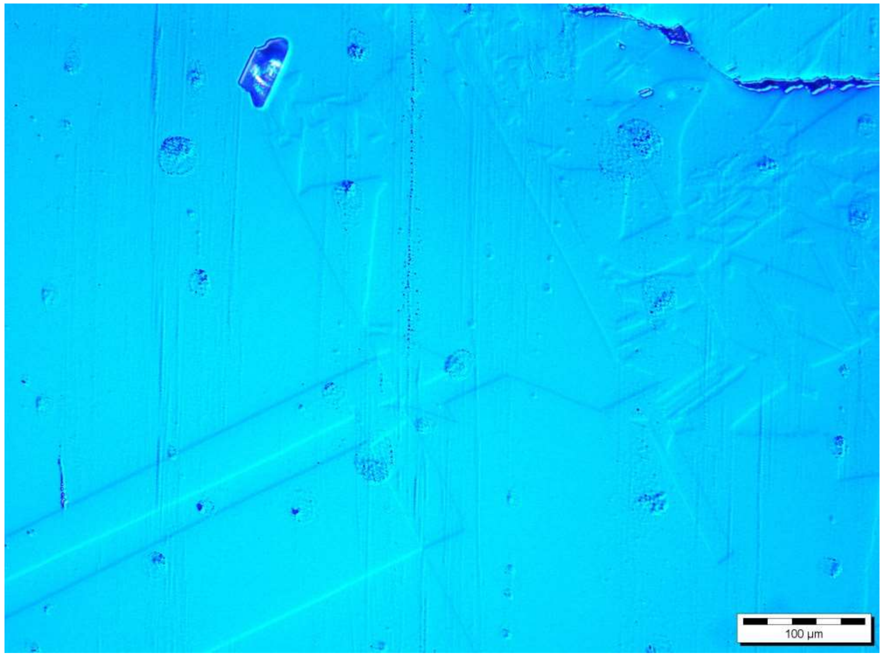
[a] $\rho = A/(\lambda^2 - \lambda_1^2)$; [b] rotatory power at $\lambda = 632.8$ nm.

Twinning in α-quartz crystals

Lamellas in quartz with
Brazil-type twins.



Graphs from R. Rykart
„Quartz-Monographie“
(Ott Verlag, Thun, 1995)



Micrograph from A. Maillard,
YAB crystal from FEE
(Univ. de Metz, 2009)
Scale bar = 100 µm

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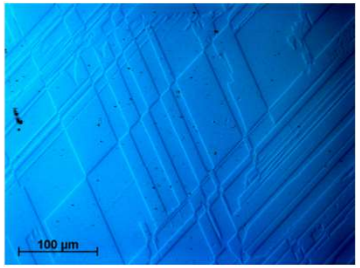
Summary and outlook

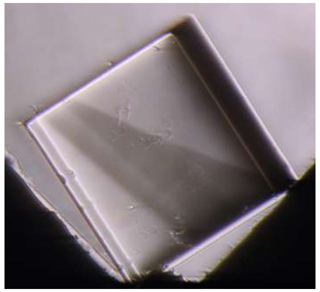
Twins in YAB are common and appear for doped and undoped crystals independently of the flux used in the growth process.

Eliminating twins is important for applications of YAB as a frequency converter.

Twins can be best analyzed by measuring the **optical activity.** A criterion has been found to determine if a crystal is twin-free.

(RE)AB crystals are also potentially interesting for:
- short pulse lasers;
- eye-safe sources;
- fluorescence standards.





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