R & D on optical materials

The goal : find an alternative to fused silica for the substrates for the next generations of core optics

Main considerations :

Physical properties :

- better mechanical Q
- same absorption level as fused silica
- better thermal properties
- good index homogeneity
- low birefringence

Technical aspects :

- availability : quality improvement
- manufacturing process (low contamination)
- cost
- polishing
- coating
- cleaning
- silica bonding

The candidates :

- sapphire (since many years)
- white yag
- fluorine (CaF_2)

	SiO_2 Fused silica	**Al_2O_3 Sapphire**	**$Y_3Al_5O_{12}$** Undopped yag	**CaF_2 Fluorine**
Density ρ [g/cm^3]	2.202	3.987	4.554	3.18
n	1.458	1.7555 1.7478	1.815	1.425
dn/dT [.10^{-6} K^{-1}]	~10	~13	9.1	-10.4
Thermal expansion α [.10^{-6} K^{-1}]	0.51	6.65 ‖a 7.15 ‖ c	7.7	19.6
Thermal conductivity κ [Wm^{-1}K^{-1}] @ 300K	1.38	46	13.4	9.71
C [Jkg-1K^{-1}]	746	777	625	887.6
Thermal diffusivity D [m^2/s] (=κ/ρC)	0.84 *10^{-6}	14.85 *10^{-6}	4.708 *10^{-6}	3.44*10^{-6}
Hardness	560	2319	1970	170
Young modulus [Gpa]	73.1	344.5	280	75.8
Poisson ratio	0.18	0.27	0.24	0.26
Absorption [ppm/cm]	0.5	50	50	2
Biref [mrad]	~1	High	?	
Quality factor Q	2*10^7	2*10^8	2*10^7	6.5*10^7
Size avail	40cm		10cm	30cm
Coating	ok	Problem	?	Ok
Polishing	0.1A rms	Hard	?	0.1A rms
Structure	amorphe	Hexagonal	cubic	Cubic

Spinel and GGG :

- laser materials not available in large size
- numbers not easy to find

Conclusion

In term of quality Q and thermal properties, the sapphire is a very good candidate, but it is not available in large size, and it is difficult to polish

The CaF_2 seems to be a good candidate, with a good Q, available in large size (the most popular material in the microelectronics), with a low birefringence, easy to polish. We need to continue the studies.

But we have to keep an eye on the fused silica, because it is improving

R & D on Data Analysis

Software:

- non linear methods for pulsar detections
- time-frequency methods (wavelets,…)
- matched filtering

Hardaware:

- clusters performances
- parallel processing machines

Future:

- increase computing power
- blind search of pulsars