



QX LASER GLASSES

These phosphate glass laser materials exhibit a chemical durability that is comparable to silicate glasses. QX glasses are designed to withstand high thermal loading and shock

PROPERTIES	QX/Nd	QX/Er	QX/Yb
Laser Wavelength Peak (nm)	1054	1535	1032
Emission Cross Section ($\times 10^{-20} \text{cm}^2$)	3.8	0.8	0.4
Absorption Cross Section ($\times 10^{-20} \text{cm}^2$)	0.7	1.7@977nm	1.4
Fluorescence Lifetime (us)	353	7900	2000
Fluorescence Linewidth (nm) FWHM	27.6	55.0	56.5
Index of Refraction (n_D)	1.538	1.532	1.535
(n_F)	1.543		
(n_C)	1.536		
(n_F) - (n_C) ($\times 10^{-5}$)	815	848	834
Abbe Number	66.0	63.7	61.1
Index of Refraction (laser line) .	1.53	1.521	1.52
dn/dt (20-40 °C.) ($\times 10^{-7}/^\circ\text{C}$.)	- 4	-21	-21
Thermo-stress Birefr. Coeff. $Q=[E/2(1-\mu)](C_1-C_2)$ ($\times 10^{-7}/^\circ\text{C}$)	9.0	9.1	9.1
Thermo-optical Coeff. $W=[dn/dt+(n-1)]$ ($\times 10^{-7}/^\circ\text{C}$) @ 70°C	59	41	41
Thermo-optical Coeff. $W=[dn/dt+(n-1)]$ ($\times 10^{-7}/^\circ\text{C}$) @ 30°C	51	33	33
Transformation Temperature (°C)	506	470	450
Deformation Temperature (°C)	535	502	485
Coeff. of Thermal Expansion (20-40°C) ($\times 10^{-7}/^\circ\text{C}$).	72	76	83
(20-100 °C)	84	88	95
(20-300 °C)		99	
Nonlinear Index n_2 ($\times 10^{-13}$ esu)	1.17	1.22	1.22
Density (g/cc)	2.66	2.93	2.81
Thermal Conductivity (W/mK)	0.85	0.85	0.85
Young's Modulus ($\times 10^{+3} \text{N/mm}^2$)	71	67	67
Poisson's Ratio	0.24	0.24	0.24
Stress Optical Coeff. $B=[C_1-C_2]$ ($\times 10^{-6} \text{mm}^2/\text{N}$)	2.1	2.3	2.3
Stress Thermal-Optical Coeff. "P" ($\times 10^{-6}/\text{K}$) $P = dn/dt - (E/2(1-\mu)](C_1+3C_2)$	-3.6	5.1	5.1
Knoop Hardness (kgf/mm^2)	503	435	435
Durability (Wt. loss $\times 10^{-5} \text{g/cm}^2$, H ₂ O, 100°C, 1Hr) ED2, Q-246, = $5.5 \times 10^{-5} \text{g.cm}^2$	5.0	5.2	5.2
Thermal Loading Limit, TLL (watts/inch) (unstrengthened)	> 300	> 150	> 300
LAMP PUMPED (strengthened)...5x80mm rod	> 900	> 450	> 900
LAMP PUMPED (strengthened)...10x150mm rod	> 500	> 250	> 500

conditions in both ion-exchanged strengthened and un-strengthened configurations.

Note: TLL = Rupture Strength. Unstrengthened QX glasses exhibit a Rupture Strength of ~ 10,000 psi. Strengthened QX glasses exhibit a Rupture Strength of ~ 40,000 psi.. The TTL is strongly dependent upon rod barrel surface conditions.

Wt% to ions/cc: $\text{Wt\%}(g)/100g \times 2.9g/cc \times 2 \text{Er}^{3+}/382.52g/\text{mole} \times 6.02 \times 10^{23} \text{ions/mole} = \text{ions/cc Er}^{3+}$

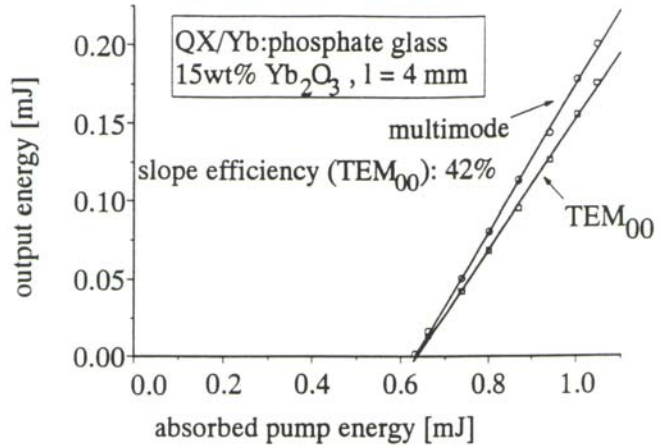
PHONE: (843) 681-5800 FAX: (843) 681-4559
E-MAIL: info@kigre.com



QX/Yb

Tunable 1025-1060nm
output, 975nm pump

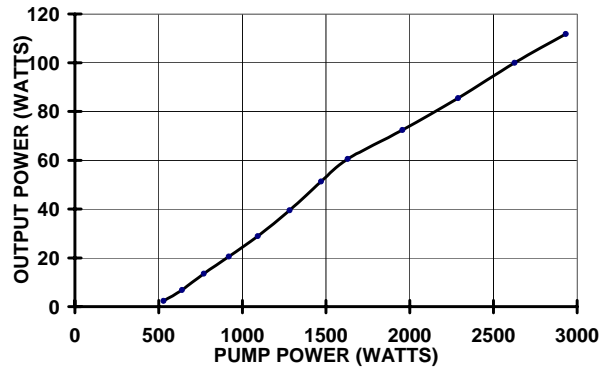
QX/Yb PERFORMANCE



QX/Nd

Lamp pump 10mm x 6"
rod, 60%R OC, 2ms PW,
5.4% Slope Efficiency

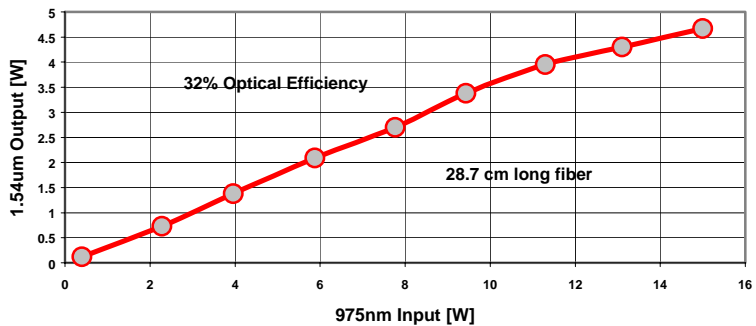
QX/Nd PERFORMANCE



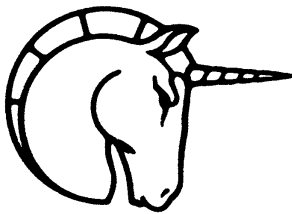
QX/Er

1.54um DC LMA
Fiber Laser

CW 1.54um QX DC Fiber Output 975nm Diode Pump



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E-MAIL: info@kigre.com



MM-2 High Gain Short Length

KIGRE, INC.

WAVEGUIDE, WDM, & FIBER 1.54um ERBIUM AMPLIFIER GLASS FOR TELECOMMUNICATIONS APPLICATIONS

Kigre's MM-2 has become a world standard 1.54um laser material for use in the next generation of EDWAs and EDFAs. It is only natural that this high performance athermal phosphate glass laser material be utilized in the evolution of the optical communications component industry.

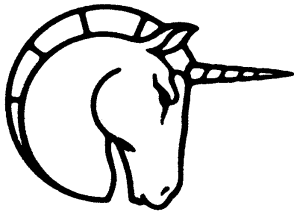
Designed specifically for telecommunications applications, this patented ion-exchangeable material is now available for use in the fabrication of miniature, monolithic, high performance C-band power splitters, EDWAs, EDFAs, gain blocks, pre-amplifiers, and (WDM) wavelength-division multiplexing integrated optical devices.

Demonstrated internal gain (waveguide configuration).....	0.5 to >3.0 dB/cm
Laser Wavelength Peak (nm)	1535
Tunable Output Range (nm).....	1520 to 1575
Emission Cross Section ($\times 10^{-20} \text{ cm}^2$) Er³⁺@1.535 & Yb³⁺@1025	0.8 & 1.4
Absorption Cross Section ($\times 10^{-20} \text{ cm}^2$) Er³⁺@1.54 & Yb³⁺@975	0.7 & 1.7
Fluorescence Lifetime (us)	7900
Fluorescence Linewidth (nm) FWHM.....	55
Index of Refraction (nD).....	1.54
Index of Refraction (laser line)	1.53
dn/dt (20-40 °C.) ($\times 10^{-7}/^\circ\text{C}$).....	-3.8
Temperature Coeff. of Optical Path ($\times 10^{-6}/\text{K}$)	3.3
Transformation Temperature (°C.).....	506
Deformation Temperature (°C.)	535
Coeff. of Thermal Expansion (20-40 °C) ($\times 10^{-7}/^\circ\text{C}$).....	72
(20-100 °C)	84
Density (g/cc)	2.70
Thermal Conductivity (W/mK)	0.85
Young's Modulus ($\times 10^{13} \text{ N/mm}^2$).....	.71
Poisson's Ratio.....	0.24
Stress Optical Coeff. ($\times 10^{-6} \text{ mm}^2/\text{N}$)	2.1
Knoop Hardness (kgf/mm^2)	435
Durability (Wt. loss $\times 10^{-5} \text{ g/cm}^2, \text{H}_2\text{O}, 100^\circ\text{C}, 1\text{Hr}$)	5.0
Note: Standard Silicate glasses have a $5.5 \times 10^{-5} \text{ g/cm}^2$ durability rating	

Custom Fiber Preforms & Fiber Pulling Also Available

Ph# (843) 681-5800 Fax# (843) 681-4559

E-Mail: kigreinc@cs Web Site: www.kigre.com



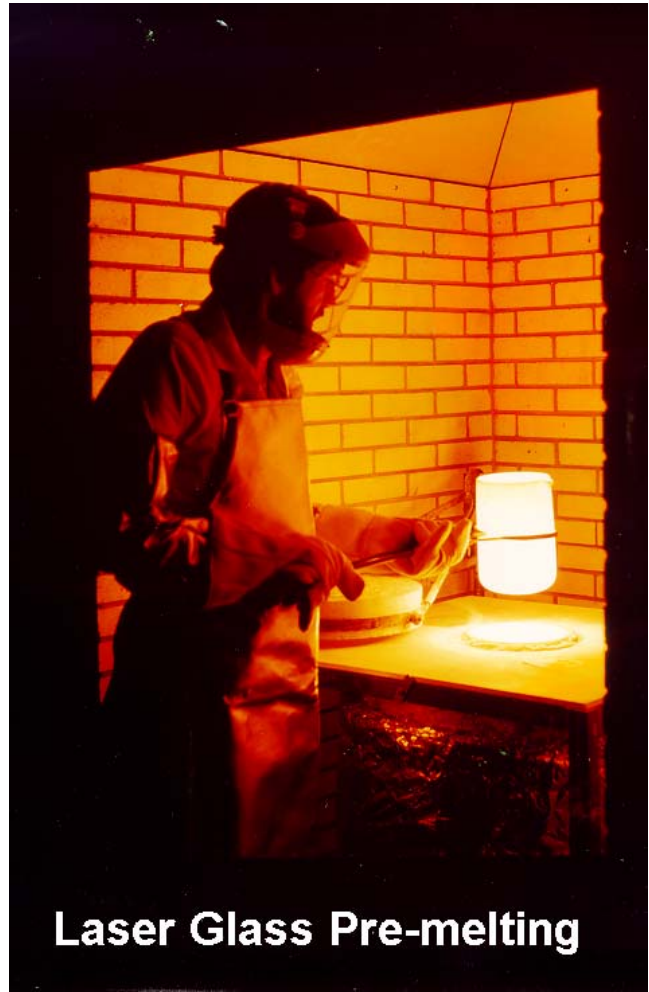
SPECIAL GLASS MELTING SERVICES

KIGRE, INC.

- Er:Yb:Nd:Laser Glass
- Filter Glass
- Faraday Glass
- IR Window Glass
- Rare Earth Doped
- Radiation Hardened
- Anti-Solarization

“Special Melts” are typically made with high performance QX phosphate glass host. The phosphate laser glasses are very popular because of their high gain, low concentration quenching and low ESA. Peak emission is for Erbium at 1.54, Neodymium at 1.05/1.3 and Ytterbium at 1.02 microns. Holmium & Thulium are doped into a germinate glass host for 2.09 micron laser operation.

Ion-exchange processing is available on many base glasses for strengthening or waveguide fabrication applications.



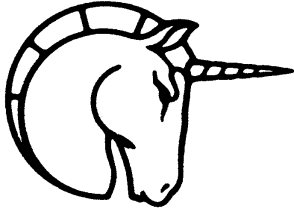
Laser Glass Pre-melting

KIGRE, INC.

100 Marshland Road, Hilton Head, SC 29926 USA

Ph: 843-681-5800 Fax: 843-681-4559

E-mail: kigreinc@cs.com



SPECIAL MELTS

KIGRE, INC.

Special Glass Melts are manufactured to customer specified dopant concentrations on a "Best Effort" basis. A typical "Alpha Special Melt" will cost \$6400.00/lot. Special melts with extra expensive components and/or high R2O3 concentrations cost \$9400.00/lot. Deliverables for an Alpha Melt typically include (2) pcs of "as cast" glass ~2" dia. x ~2.5" thick. Other sizes and shapes are available upon customer request. We encourage customers to use our standard 2.1", 2.75" or 10 cm diameter round shaped casting molds in order to insure an optimum yield of laser grade optical quality material. Alpha's special melt delivery schedule typically runs ~ 6-8 weeks after receipt of order. Less expensive "Hand Melts" and "Button Melts" are also available.

Kigre special melt services offer a wide selection in base glasses, dopants, and dopant concentration options. Standard base glasses are phosphate, silicate, germanate, and borate. These glasses are typically doped with Rare Earths. In general, the maximum R2O3 concentration (Wt%) is ~25% for phosphate glasses, 10% for silicate glasses, and 60% for borate glasses. The QX phosphate glasses are popular due to their high gain, chemical durability, low ESA losses, insensitivity to clustering, high strength, broad absorption and emission bands, and chemical strengthening ion-exchange properties.

Spectral Transmission samples of Kigre's stock glasses are available at \$540.00 each. A typical transmission sample is approximately 1" x 1" x 1 cm path length. Transmission Samples are "Window Polished".

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Ph# 843-681-5800 Fax# 843-681-4559

E-mail kigreinc@cs.com

Web Site: www.kigre.com



KIGRE, INC.

Custom Fiberoptic Preforms

High Gain Rare Earth Doped Glasses For Fiber Laser & Fiber Amplifier Applications

Kigre, Inc. now manufactures customized rod-in-tube Erbium, Ytterbium, Neodymium and Er:Yb:Glass fiberoptic preforms. In Addition, Kigre provides special glass melting and fiber pulling services.

Custom fiber preforms are typically manufactured from "Special Melts". Special melts are typically made with a high performance QX phosphate glass and a combination of Erbium and/or Ytterbium for 1.54um operation. Neodymium for 1.05 or 1.3um operation. Single, double and triple clad preform designs are combined with a wide range of step index changes and preform shapes and sizes.

Fig. 1. Fiber Pulling

MM-2, QX/Yb & QX/Er:phosphate glass rod-in-tube preforms are pulled into a 250um dia. single or multimode fiber. Kigre also offers special "mini" drawing tower services for the pulling of small quantity R&D "test" fiber preforms.

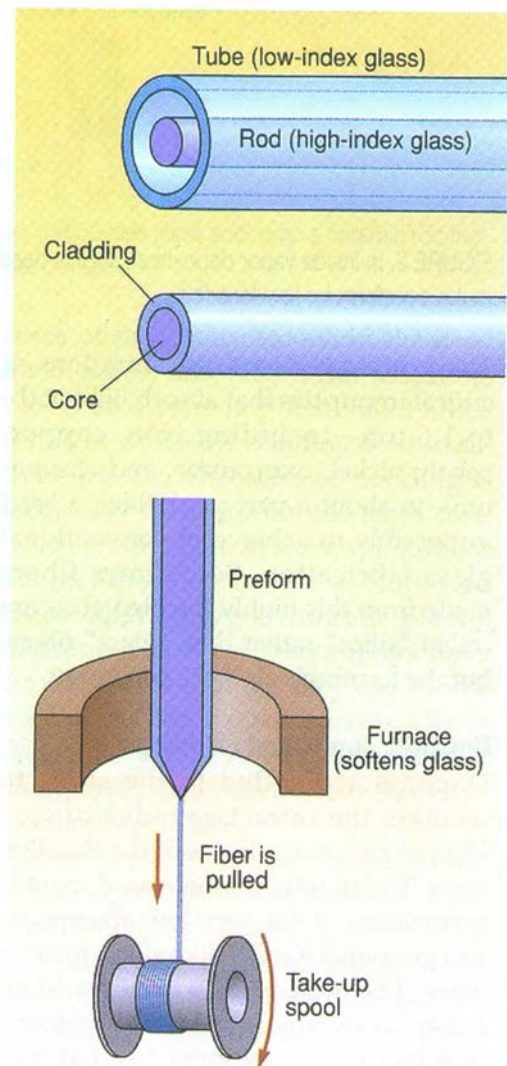


Fig. 1

**Kigre, Inc. 100 Marshland Rd., Hilton Head, SC 29926, Ph# 843-681-5800,
Fax# 843-681-4559, E-mail: kigre@aol.com Web Page: www.kigre.com**



Kigre Custom Fiber Laser Components

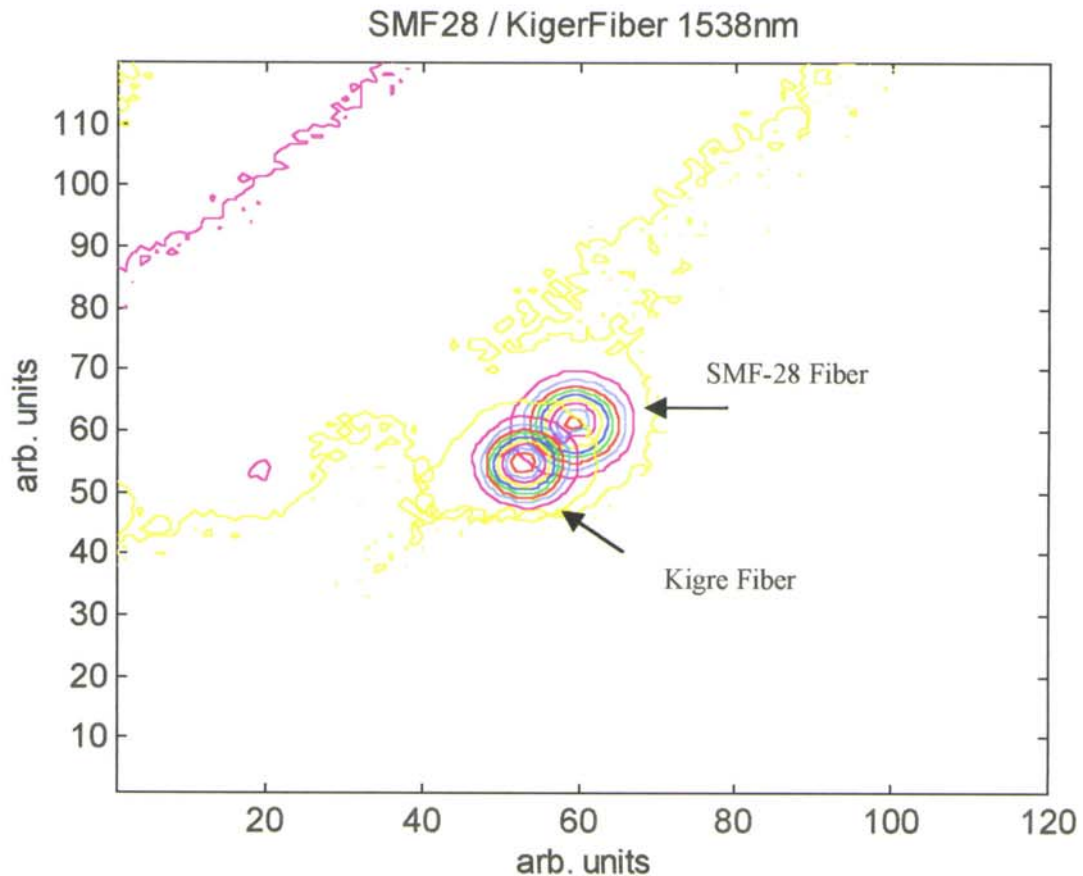


Fig. 2. Fiber Laser Mode Match

The above figure shows an example of Kigre's capabilities in the manufacture of Custom Fiberoptic Preforms and pulling of Fiber Laser Fiberoptic oscillator and/or amplifier material. Kigre's Er:Yb:phosphate glass single mode fiber propagation mode profile is captured on an IR vidicon illustrating the high degree of circular symmetry at 1538nm.

Note: SMF-28 = a standard single mode Corning communications fiber.

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