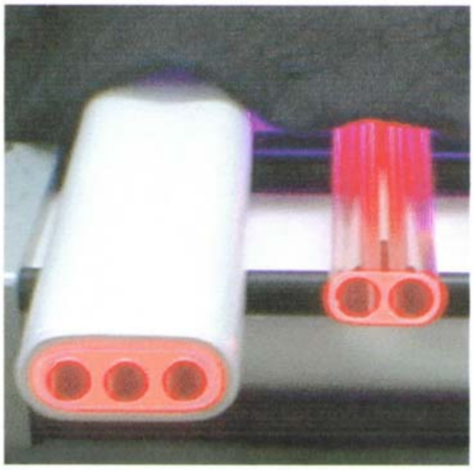
KIGRE, INC.

SOLID-STATE LASER COMPONENTS



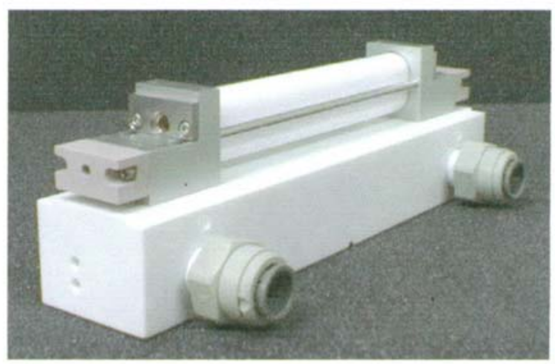
PUMP CAVITIES

SAMARIUM FILTERS

DIFFUSE REFLECTOR

SAMARIUM FILTERS & DIFFUSE REFLECTOR ASSEMBLIES

Kigre's Filter Flowtubes & Diffuse Reflector Pump Cavities combine a close coupled intracavity filter with a high density $BaSO_4$ reflector. This combination exhibits spectral & thermal management properties which are unsurpassed in performance by any other cavity.



LASER ROD LAMP PUMP CHAMBER DESIGNS AVAILABLE!

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

KIGRE, INC.

SOLID-STATE LASER PUMP CAVITY REFLECTORS

During the 1970's and 1980's Kigre developed a series of intra-cavity filters and solid-state, diffuse reflector laser cavity reflectors based upon very unique high performance designs. Numerous manufactures have employed Kigre cavity reflectors and filter flow tubes into their standard line of commercial and OEM laser products. Competitive attempts to match Kigre's cavity reflector performance have consistently fallen short of the mark. "Other" designs have only been able to emulate to a limited degree the wide operational envelope, unlimited lifetime, and overall performance of the real thing. Kigre's close-coupled intra-cavity reflector assemblies exhibit spectral management properties that are unsurpassed in performance by any other cavity.

COMPARISON OF REFLECTIVE MATERIALS (%R)

WAVELENGTH (nm)	GOLD	$BaSO_4$	SILVER	ALUMINUM
300	0.35	0.95	0.10	0.95
400	0.33	0.99	0.99	0.93
500	0.40	0.99	0.98	0.92
600	0.76	0.99	0.98	0.91
700	0.92	0.99	0.99	0.90
800	0.94	0.99	0.99	0.90
900	0.94	0.99	0.99	0.90
1000	0.95	0.99	0.99	0.90

Diffuse Reflector Pumping Cavity Attributes

A.) **Multi-pass Absorption**

A diffuse pump cavity reflector assembly is in many ways similar to an integrating sphere. The flashlamp or arclamp energy is diffusely reflected many times before being absorbed in the active gain media.

Specular reflectors are designed to focus the emitted light from the flashlamp into the active gain media. Little if any consideration is given to light that may have passed through the gain media due to weak absorption or Fresnel reflection. This energy is absorbed in either the pump chamber reflector or reabsorbed in the flashlamp plasma.

In a diffuse reflector pump cavity, light that has passed through the active gain media has a good probability of passing through the media again, allowing for further absorption of some of the weakly absorbed flashlamp spectra. Depending upon the reflector, rod, and flashlamp geometry, the flashlamp energy may pass through the active gain media up to two times more in a diffuse reflector pump cavity chamber than in a specular reflector pump cavity. In practice, this allows the Laser Engineer the ability to reduce the dopant concentration or the diameter of the active gain media without sacrificing efficiency. This can be advantageous when pumping a highly absorbent gain media at high average power.

B.) **Resistance to Degradation**

Most medium or high power lasers that utilize specular pump cavity reflectors require active cooling of the reflector. The two most commonly used methods include direct coolant contact with the reflector or conduction through the reflector into a heat sink. In either case the life of the reflector is limited because of impurities in the coolant or differences in thermal expansion or quite simply corrosion.

Kigre's series of diffuse reflector pump cavity assemblies utilize a reflector that is in the form of a high-density powder separated from the coolant by a glass flowtube. The powder (Barium Sulfate $BaSO_4$), is an extremely inert compound guaranteeing long life. In order to ensure long life and high performance, Kigre utilizes a proprietary powder purification and densification process.

Because of the inertness of the reflector and the protection of the filter/flowtube, the life of the Kigre pump cavity reflector assembly is indefinite if the coolant used is rather pure (usually ~1MΩ/cm H_2O). Many Kigre pump cavity reflector assemblies have been providing decades of service without maintenance.

C.) **Parasitic Oscillation Suppression**

In high gain active laser media, parasitic oscillations may limit the maximum stored energy and thus the maximum gain. This is particularly true for materials like Nd:YAG when used as Q-switched oscillators or amplifiers. It is possible, in pumping chambers utilizing specular reflectors, that parasitic oscillation paths may reflect off the specular reflector itself limiting or “clamping” the stored energy.

Unlike a specular reflector, a diffuse reflector provides a near Lambertiam distribution, reducing the possibility of parasitic oscillations reflecting off the pump chamber reflector. In addition to the parasitic oscillation suppression offered by the use of a diffuse reflector, Kigre pump cavity reflector assemblies provide further parasitic suppression through the use of a doped flow tube or “filter tube.” Kigre manufactures filter tubes doped with various dopants for nearly all solid state laser materials.

D.) **Pumping Uniformity**

Specular reflector cavity reflectors are often engineered to provide as uniform pumping as possible, often at the expense of efficiency. When specular reflector pumping chambers are designed for maximum efficiency the pumping uniformity is usually quite poor leading to “hot” spots in the laser output beam and uncorrectable thermal lensing in the laser rod.

The near Lambertian distributions of diffuse reflections provide the diffuse reflector pumping chambers with significantly improved pumping uniformity over that of specular reflector pump chamber designs. Because the rod is illuminated more symmetrically, it is easier to compensate for thermal induced lensing and birefringence.

E.) **Higher Reflectivity than Gold, Ceramic, or Silver Reflectors**

In addition to the inertness of the diffuse reflector, $BaSO_4$ has higher reflectivity (better than 98% form 375nm to 1.3μm) than gold, ceramic, or silver coatings. The high reflectivity coupled with the inertness provides superior performance over specular reflectors.

F.) **Higher Efficiency**

More of the flashlamp or arclamp energy is couples into the active gain media with a diffuse reflector than with a specular reflector. Under equal pumping conditions, the diffuse pump cavity offers reduced thresholds, increased slope efficiency, overall efficiency, more stored energy, and higher gain.

G.) **Unique Advantages of Kigre Diffuse Reflector Pump Cavity Reflector Assemblies**

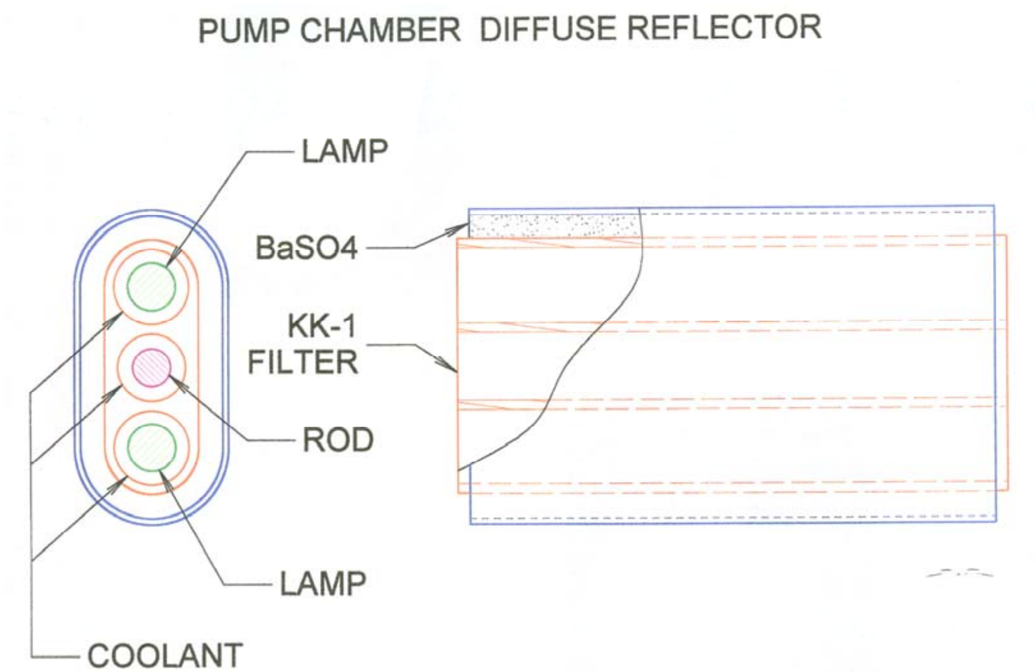
Kigre pump cavity reflector assemblies are constructed with the diffuse reflector placed on the outside of the glass filter tube. The filter tube is usually in the shape of a double or triple barrel shotgun with a web of glass separating the active gain media bore from the flashlamp or arclamp bore. Since the index of refraction of the glass between the rod and the lamp is higher than water or air, the active gain media is optically “moved” closer to the flashlamp or arclamp providing even closer coupling for higher efficiency.

Through doping the filter tube, portions of the flashlamps spectrum that are unwanted may be filtered from reaching the gain media. The solid state gain materials that are somewhat sensitive to UV solarization may be protected by such a filter tube. Depending upon the nature of the gain media, Kigre utilizes Cerium and Samarium and other dopants to absorb ultraviolet (UV) and portions of the visible spectrum. Some of this absorbed energy is emitted through fluorescence in a spectral region that is absorbed by the gain media. By absorbing the non-useful portions of the lamp’s spectrum, the temperature of the gain media may be lowered, reducing thermal effects such as lensing and birefringence.

Kigre’s diffuse reflector pump cavity reflector assemblies utilize a “close coupling” design for maximum efficiency. In addition to the increased efficiency, the diffuse reflector pump cavity is usually smaller in size and mass than comparable specular pump cavities.

Useful optical pumping of solid state laser material usually is in the region of 400 - 1300nm. Kigre has designed its diffuse reflector pump cavity assemblies to transmit flashlamp or arclamp light that is longer than 1.5μm and less than 3μm through the diffuse reflector, reducing absorbed heat in the gain media and thus reducing lensing and birefringence.

Kigre has manufactured several thousand diffuse reflector pump cavity reflector assemblies during the last two decades that accommodate solid state laser rods ranging from 3mm ∅ x 30mm to 25mm ∅ x 600mm. In most situations a pump cavity reflector assembly has been already designed for a customer's specific needs; however, many custom filter/flow tubes and reflector assemblies are fabricated each year.



KIGRE, INC.,
100 Marshland Road, Hilton Head, SC 29926
Phone: (843) 681-5800 Fax: (843) 681-4559
E-mail: kigreinc@cs.com Web Site: www.kigre.com