

GAM LASER, INC.

UNIQUE FEATURES OF GAM LASER EXCIMER LASERS

The GAM Laser, Inc. excimer laser products offer a number of unique and advanced design features which results in the longest dynamic and static gas lifetimes of any available excimer lasers.

1) Corona preionization

Corona preionization. All GAM lasers are preionized with a soft corona discharge. Unlike lasers which utilize outdated UV spark preionization or sliding spark preionization, true corona discharge preionization is a uniform, low current, distributed glow gas discharge which does not produce electrode erosion or consume the active laser gas. Spark discharge is the opposite, a high current, localized, intense spark, which vaporizes electrode material and consumes and contaminates the active laser gas. Spark preionization also produces high EMI and generates high dust levels within the laser chamber. The corona discharge system in GAM LASER excimer lasers shows minimal wear after billions of pulses and unlike spark preionized lasers, never requires replacement. Corona discharge provides a long term stable preionization method which gives increased gas lifetime and increased optics lifetime due to low dust levels. Additionally, due to the high uniformity of corona preionization the laser output gives excellent (<2%) pulse stability. Older technology spark preionized lasers can usually be identified by the poor pulse to pulse stability, typically +/-4% or worse.

2) Advanced materials

Total Metal/Ceramic Design Total Metal/Ceramic design means that all laser components are either chemically stable ceramics or carefully selected pure metals. No plastic is used anywhere in the laser chamber. Plastics were used extensively in early excimer lasers and are still used today in a number of lasers. Many lasers claiming to use a metal/ceramic design still in fact use numerous plastic parts. Lasers containing plastics show poor gas dynamic lifetime and can be easily identified by the very poor static gas lifetime. Even if a laser containing plastics is left unused, the gas still needs replacement every few days, the exact lifetime depending upon the excimer gas used. XeCl gas fill is more tolerant of plastic components and can last a week or more even with plastic components in a laser. Compare this with the GAM Laser total metal/ceramic design where XeCl static gas lifetime is over 2 years.

Plastics also reduce the optics lifetime of excimer lasers. Fluorocarbons and Chlorocarbons produced in chemical reactions with the plastic materials are photo deposited on the internal optical surfaces and rapidly reduce the laser output energy and damage the optics. Lasers with plastic components typically require optics service an order of magnitude more frequently than metal/ceramic lasers.

The unique total Metal/Ceramic design of GAM lasers gives the longest dynamic and static gas lifetimes of any excimer lasers and produces long optics lifetime.

3) Internal vacuum pump and Halogen filter

Internal Vacuum Pump and Halogen Filter All laser models feature an internal vacuum pump, solenoid valve manifold and Halogen filter. The vacuum pump is used when the active laser gas in the laser chamber is replaced. The used gas is passed through a high capacity Halogen filter and all Fluorine or Chlorine is removed. The Halogen filter is rated for approximately 1000 refills of the laser head, and is replaced during laser head service. The internal vacuum pump system and computer control insures reliable, hands off, repeatable gas refills without the use of any external

vacuum components and bulky stand alone vacuum pumps or halogen filters. Additionally the internal vacuum pump allows for a complete contamination free gas replacement, unlike excimer lasers which use gas flow through only to replace the active laser gas. The vacuum pump provides a more reliable method of gas exchange than simple flow through.

In normal operation a single cylinder of premix gas is attached to the appropriate laser gas port. Refill of the laser, including pumping out the old gas and refilling with fresh gas from the premix cylinder is accomplished completely automatically from software.

4) Unique chamber design with 50 microradian pointing stability and active stabilization.

Pointing Stability. The pointing stability of all GAM lasers is maintained by a proprietary control technology which actively stabilizes the laser pointing to within $\pm 20\mu\text{Rad/C}$. The stabilization is active under all operating conditions. This technology avoids power fluctuations due to changes in mirror pointing and allows for precise, long term pointing of the laser output under changing ambient and operating conditions. The laser alignment remains constant over the long term without tweaking. Additionally the low divergence of GAM LASER excimer lasers, typically a factor of 3-5 less than large beam lasers, allows tight focusing of the output beam for precision cutting and machining.

The EX50 and EX100 lasers produce very low divergence with the standard stable resonators, this gives excellent focusability. The divergence is sufficiently low to produce air breakdown. Normally this requires unstable resonator configurations for most excimer lasers.

5) Internal energy Monitor

Internal Energy Monitor All GAM LASER excimer lasers are equipped with an internal energy monitor. The energy detector is used to measure the energy of every laser pulse and is used in conjunction with the EXLASER software package to monitor the output energy and average power of the laser. Long term energy stabilization is maintained with the internal energy monitor and software feedback control. The energy stabilization range is approximately 40% to 95% of specified maximum energy output.

An optional feature allows automatic NIST traceable calibration of the internal energy monitor.

6) Gas Lifetime

Gas Lifetime. Gas lifetime is one of the most important parameters of an excimer laser. The total metal/ceramic design of GAM Laser products and the careful choice of pure metals and ceramics in the laser chamber, produces the longest static and dynamic gas lifetimes of any excimer lasers. The static gas fill lifetime with a single gas fill and **no halogen injections or cryogenic add on's**, of GAM lasers with XeCl is up to 1 year. KrF gives up to 12 weeks of static gas lifetime. Dynamic gas lifetimes of greater than 100 million pulses can be obtained with KrF at 248nm in industrial systems. Total metal/ceramic design also results in maximum optics lifetime and high pulse stability, better than 2% standard deviation.

Vacuum ultraviolet Fluorine operation at 157nm poses the stiffest lifetime test for any excimer laser, lifetimes as short as 100,000 pulses were obtained from most lasers until recently, and typical static gas lifetime for most F2 lasers at present is only 24 hours. The total metal/ceramic design of GAM LASER excimers gives 10 times longer gas life at 157nm than all other excimer lasers. For example, the EX50F laser gives over 10 million pulses to 50% energy at 157nm with a static gas lifetime of greater than 15 days.

High laser efficiency also increases the gas lifetime. The advanced design of the Pulse Power Driver in the EX series of lasers results in very high laser efficiency, over 5% with KrF. This greatly increases gas lifetime and decreases electrode wear.

7) Software

Versatile Software Control. All GAM lasers are controlled from a PC. The EXLASER software package allows the user to program and remotely control all laser functions. The laser is controlled through a high speed link which allows pulse to pulse control at the highest laser repetition rates. The entire EXLASER software control package can be updated directly over the Internet or through phone lines. The laser can be operated remotely and allows for remote diagnostics. EXLASER software provides complete laser operational control from the Windows™ 9x/2000/NT environment. The software gives complete “on the fly” control of the laser, displays graphical information on the laser performance, allows controlled burst mode operation, controls gas handling, calibrates energy output and can be set for long term automatic operation. A 32 bit DLL (Active X) is also available for OEM users or those who wish to create custom laser software or to incorporate the EXLASER software into a larger software package for the Windows™ 9x/2000/NT operating environment.

All lasers can be externally triggered by a user supplied trigger pulse. A sync out pulse provides a timing reference for triggering experimental systems.

EXLASER software requires a PC with a 386 processor or better, 10MB of hard drive space, CD-ROM and 8MB RAM.

8) Unstable Resonator Option

Unstable Resonator Optics Unstable resonator optics provide greatly reduced beam divergence. The decreased beam divergence produces smaller focused spot sizes and much increased laser intensity.

The unstable resonator optics produce divergence's of less than 100 microradians. This allows air breakdown (a measure of the focused intensity of the beam) at very low energy output. For example 8mJ causes air breakdown with an EX10 laser equipped with unstable resonator optics at 193nm.

The unstable resonator optics also give the exceptional pointing stability of better than +/-50 microradians shown with all GAM Laser, Excimer laser products.

Unstable resonator optics also give increased coherence properties. The coherence length at 248nm is increased by an order of magnitude to approximately 2mm.

Unstable resonator optics can be rapidly retrofitted to all laser products in the field. Output energy at all wavelengths is reduced to approximately 70% of stable energy output in the near field. Unstable resonator optics are available for 157nm, 193nm, 248nm, 308nm and 351nm.

9) Long Coherence Length Line Narrowed Systems

Line Narrowing The output spectrum of free running KrF and ArF excimer lasers is a broad spectral band a few hundred pm wide. This broad spectral output can be narrowed using a resonator with wavelength dispersive elements to produce a linewidth of less than 1pm. The narrow line output gives a longer coherence length and a much higher spectral intensity than standard excimer lasers. The EX50LN produces stable linewidths of less than 1pm over wide tuning ranges centered at 193.3nm and 248.35nm.

Coherence The temporal coherence length of the standard EX10 laser equipped with stable resonator optics is KrF at 210μ FWHM at 248nm and 90μ FWHM at 193nm. The relatively long coherence length makes the laser ideal for writing fiber Bragg gratings. Spatial coherence length can be increased by approximately an order of magnitude with the unstable resonator optics sets. Much longer temporal lengths can be obtained from line narrowed lasers. The EX50LN has a temporal coherence length of approximately 7cm at

10) Service Issues

Service Considerations GAM LASER excimer lasers are designed to minimize service events. Service considerations common to all excimer lasers and the order of occurrence are:-

- a) Gas Replacement: The active gas in the laser chamber requires replacement. The interval between gas replacements depends upon the number of pulses obtained per gas fill, for example with KrF gas, replacement is required every 30 Million pulses with the EX50 Laser. This gas replacement procedure is handled automatically by software.
- b) Optics Service: This is the cleaning or replacement of the laser mirrors. The mirrors acquire dust on the internal surfaces and can also be damaged by the UV laser light. The interval between optics cleaning or replacement depends upon the laser active gas, for example it is required every 500 Million pulses with the EX50 and EX10 lasers operating on KrF.
- c) Gas cylinder replacement: This is required approximately every 1 billion pulses with a 2000 liter gas cylinder on an EX50 with KrF. Larger cylinders are available. Industrial versions give 2-3 Billion pulses from a 200 liter gas cylinder.
- d) Chamber Service: This is required approximately every 2-3 billion pulses. The chamber is rebuilt at the factory and returned to “as new” specifications.