LASER DIODE IGNITION ACTIVITES AT SANDIA NATIONAL LABORATORIES

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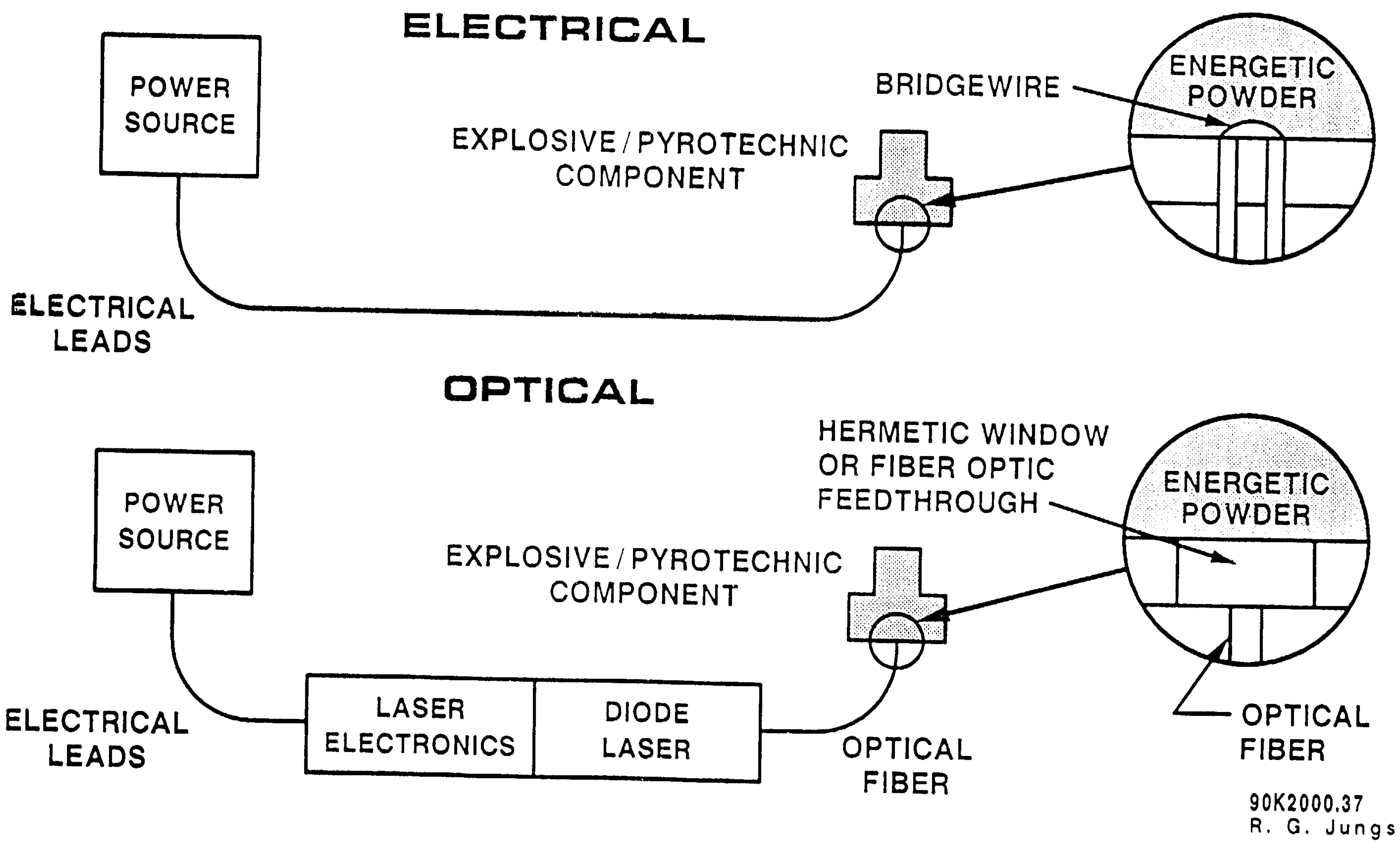
IGNITION SUBSYSTEMS



WHY?

ENHANCED SAFETY

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Optical Ordnance Power Densities in W/cm^2

	Laser Diode Ignition (LDI)	Pulsed Laser Ignition (PLI)	Direct Optical Initiation (DOI)
Threshold	10^3	10^5	10^9
Operational	10^4	10^6	10^{10}
		Thermal Ignition	Shock Initiation

LOW ENERGY OPTICAL ORDNANCE PROGRAM

OBJECTIVE: Develop optically ignited devices to replace low energy, hot wire igniters, detonators, and actuators.

CONCEPT: Transmit optical energy from a laser source to an explosive or pyrotechnic via a fiber optic. The fiber is coupled to the powder through a hermetically sealed window, fiber feedthrough or a reimaging lens window system.

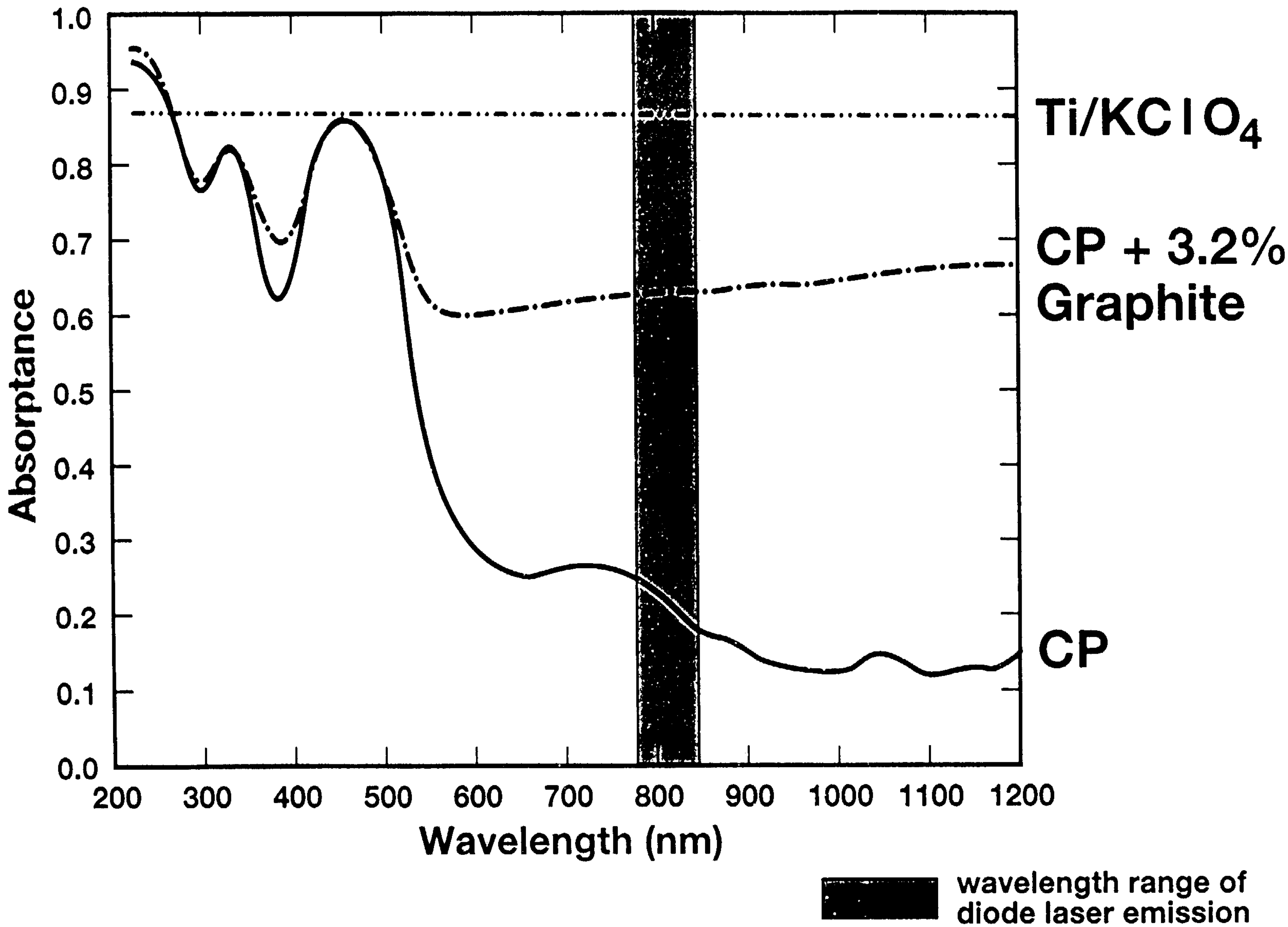
ADVANTAGES: The absence of a bridgewire and electrical leads eliminates powder/bridgewire interface decoupling and corrosion concerns. No fire, CAF, ESD, EMR, and IR concerns are reduced.

Input energy required is comparable to hot wire devices.

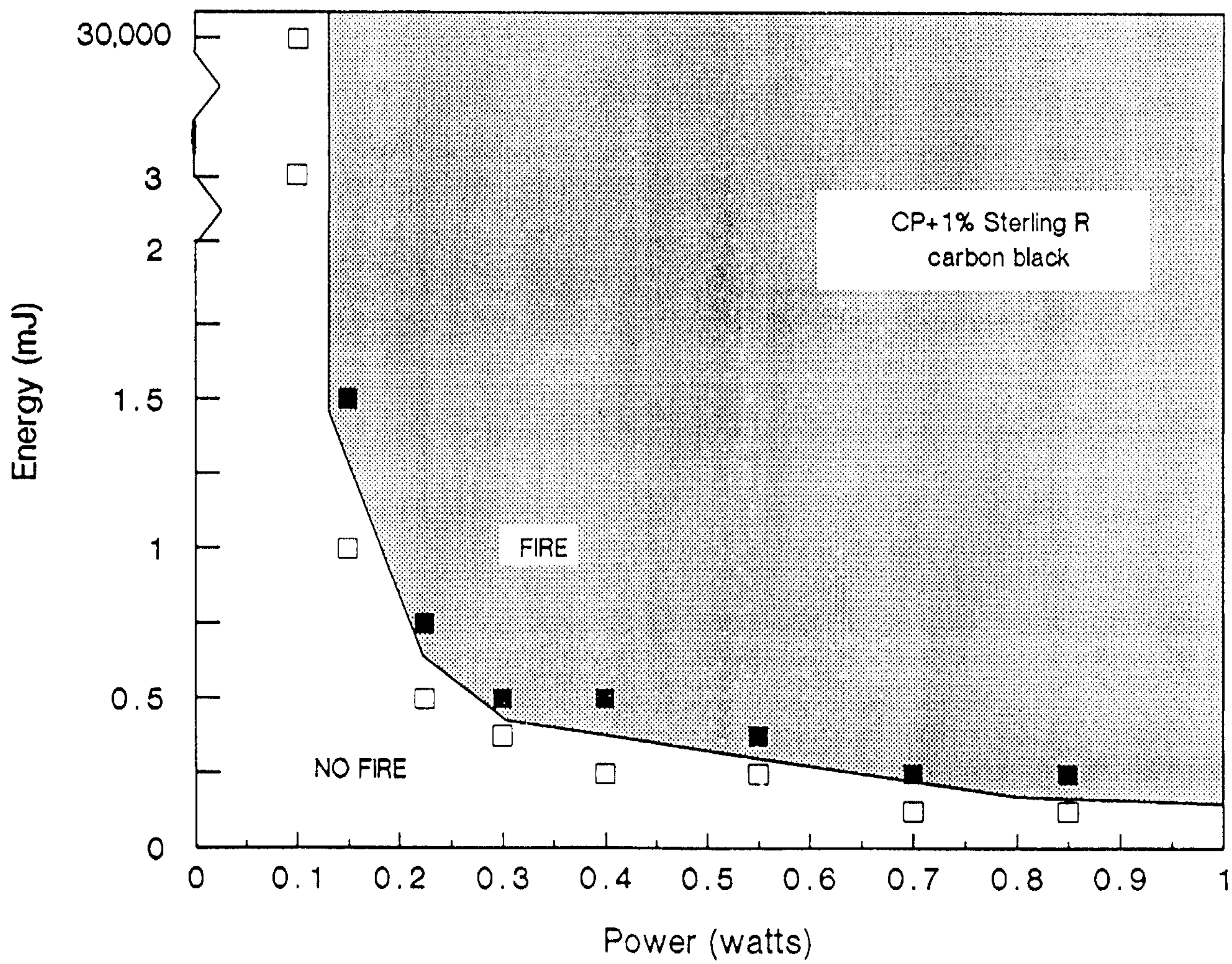
OPTICAL IGNITION FACTORS

- Energetic Material Characteristics:
  - Optical Absorptance at Laser Wavelength
  - Ignition Temperature
  - Thermal Conductivity
- Laser Energy Delivery:
  - Pulse Width and Height
  - Spot Size
  - Wavelength
- Optical Header Properties:
  - Thermal Conductivity
  - Beam Divergence
  - Powder Confinement

The absorptance of CP near 800 nm can be enhanced by adding dopants



LASER DIODE IGNITION PROJECT
POWER DEPENDENCE OF DOPED CP



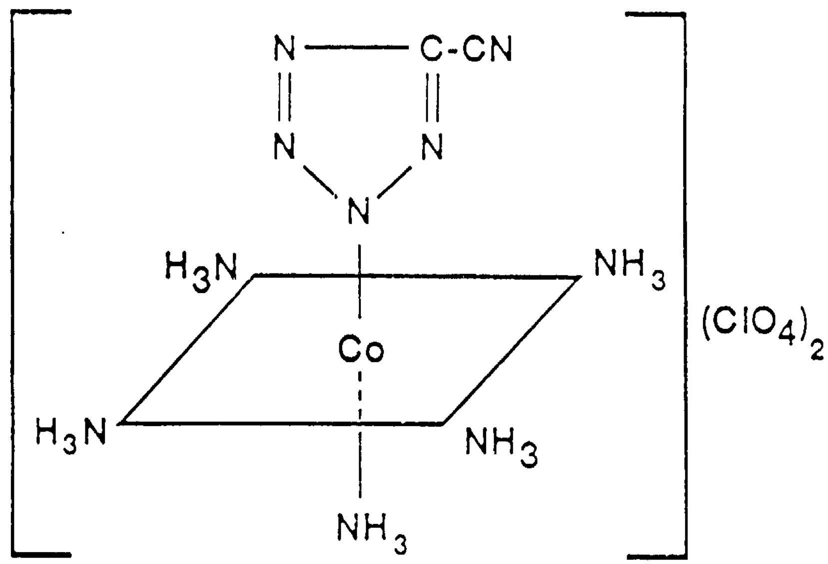
JS/2512

System Operational Electrical Requirements

Device	Voltage (V)	Current (A)	Pulse Width (ms)	Energy (mJ)
SNL hot wire -- CP	3.5	3.5	1.75[a]	21
SNL hot wire -- Tl/$KClO_4$	3.5	3.5	1.75[a]	21
SNL hot wire -- Barium Styphnate	2.5	0.56	4[a]	5.6
LDI -- CP (doped)	3.0	3.0	0.88[b]	7.9
LDI -- Tl/$KClO_4$	3.0	3.0	1.76[b]	16

[a]wire burn out time
[b]three times an ignition charge function time at 0.85 watts laser power

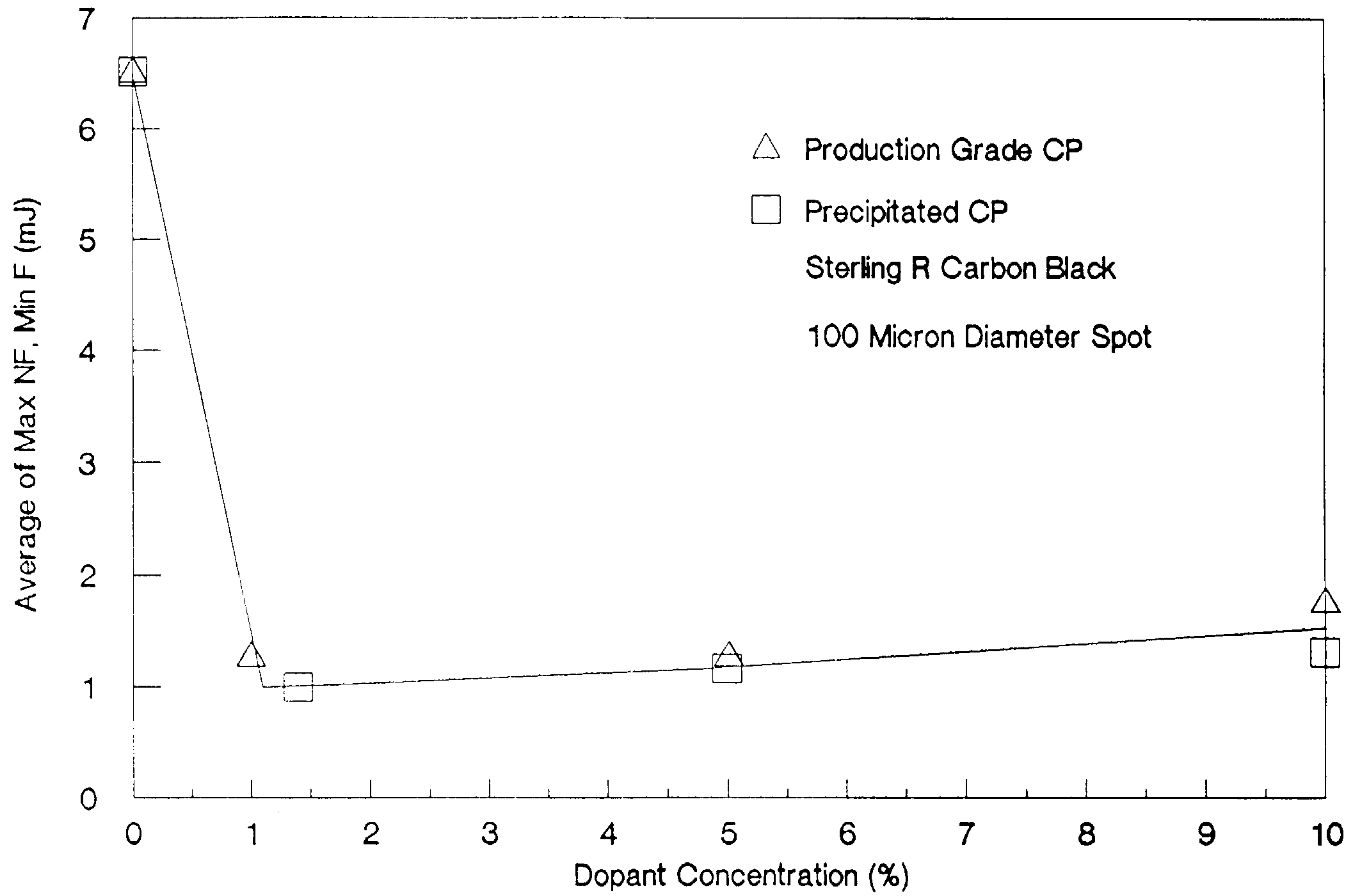
THE DDT EXPLOSIVE, CP



2-(5-cyanotetrazolato)pentaamminecobalt(III) perchlorate (CP)

Particle size:
- production grade 15 μm
- precipitated 4-6 μm

DOPANT CONCENTRATION EFFECTS FOR DIFFERENT CP PARTICLE SIZES



Zr/$KClO_4$ Optical Ignition Thresholds

Thresholds

Ambient (20 C)		Liquid Nitrogen (−196 C)	
Highest no-fire	Lowest fire	Highest no-fire	Lowest fire
3.0 mJ	3.25 mJ	3.0 mJ	5.0 mJ *

Density = 2.7g/cc (10 Kpsi loading pressure)

100 micron fiber

10 ms pulse width

* Limited number of units tested

LDI Liquid Nitrogen Test Results

Units fired at 77 K or −196 C

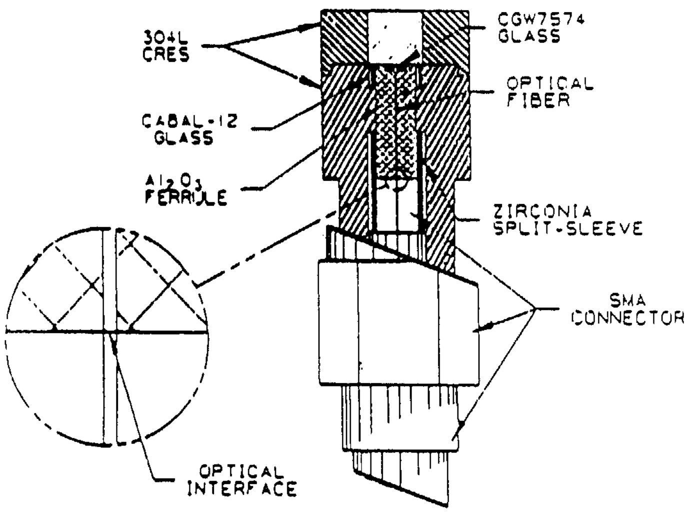
Header Type	Energy Levels	Results
Sealed Fiber Header	1.8/3.0 mJ	No Fire/Fire

Powder--CP/1% Carbon Black

Typical Threshold at Ambient is 1.25 − 1.50 mJ

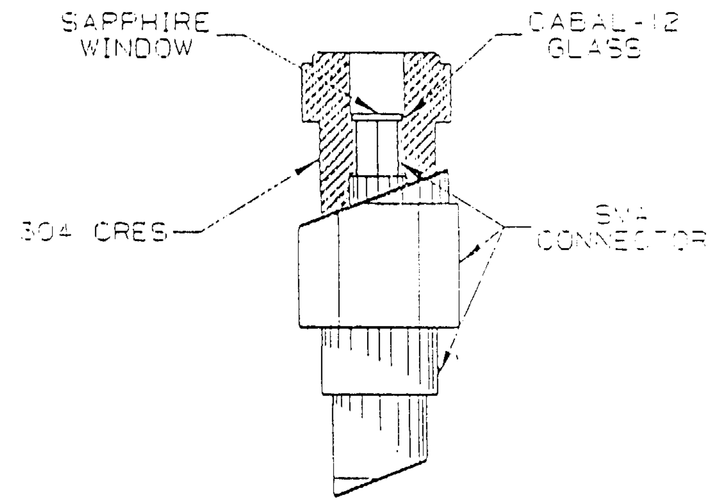
Electrostatic Discharge Testing

CONNECTOR-READY OPTICAL FIBER WINDOW SEAL



2 ea. CP
2 ea. Zr/$KClO_4$

CONNECTOR-READY SAPPHIRE WINDOW SEAL



2 ea. CP
2 ea. Zr/$KClO_4$

Both Header Types Survived The Sandia Severe Electrostatic Tester (Fischer Model) With a 25 KV Input Pulse

SANDIA LOW ENERGY OPTICAL ORDNANCE PROGRAMS

MAST (Multiple Application Surety Technology)

- Baseline LDI Subsystem

STEP (Stockpile Transistion Enablement Program)

- Family of LDI Components for Future Applications

FOCAL POINT

- Baseline LDI Subsystems as part of Other Adv. Dev. Projects

INTERNAL ADVANCED DEVELOPMENT

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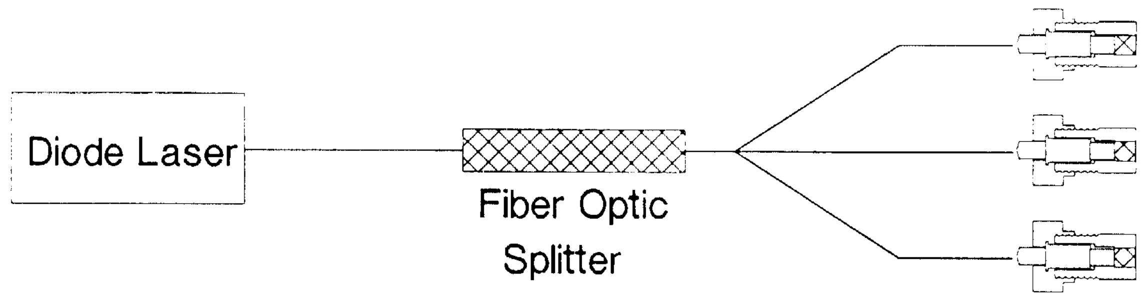
Laser Diode Ignition of 3 ea. Devices

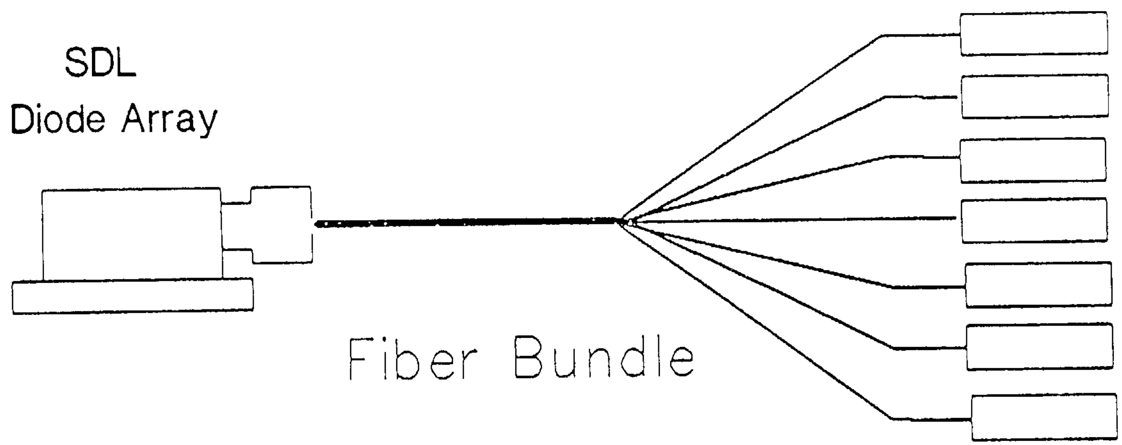


Leg	Energy Level (mj)	Function Time (ms)
1	2.13	1.63
2	2.08	1.80
3	2.03	.892

- 1 Watt, 10 ms pulse out of Diode Laser

JS/SNL

Laser Diode Ignition of 7 ea. Devices



Leg	Energy Level (mj)	Function Time (ms)
1	2.74	3.00
2	3.16	2.10
3	2.79	2.40
4	2.59	3.26
5	3.10	1.81
6	3.80	1.73
7	2.85	2.11

SUMMARY

Low energy ignition represents an effective replacement for hotwire devices.

The removal of the bridgewire eliminates ESD and EMR concerns.

Multiple explosive functions have been demonstrated using both a single laser diode and a laser diode array.

Feasability of low energy optical ordnance has been demonstrated and the technology is now ready for full scale engineering development.

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