N93-20142

LASER DIODE IGNITION ACTIVITES AT SANDIA NATIONAL LABORATORIES

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Presented to
NASA/DOD/DOE Pyrotechnics Systems Workshop
June 9-10, 1992

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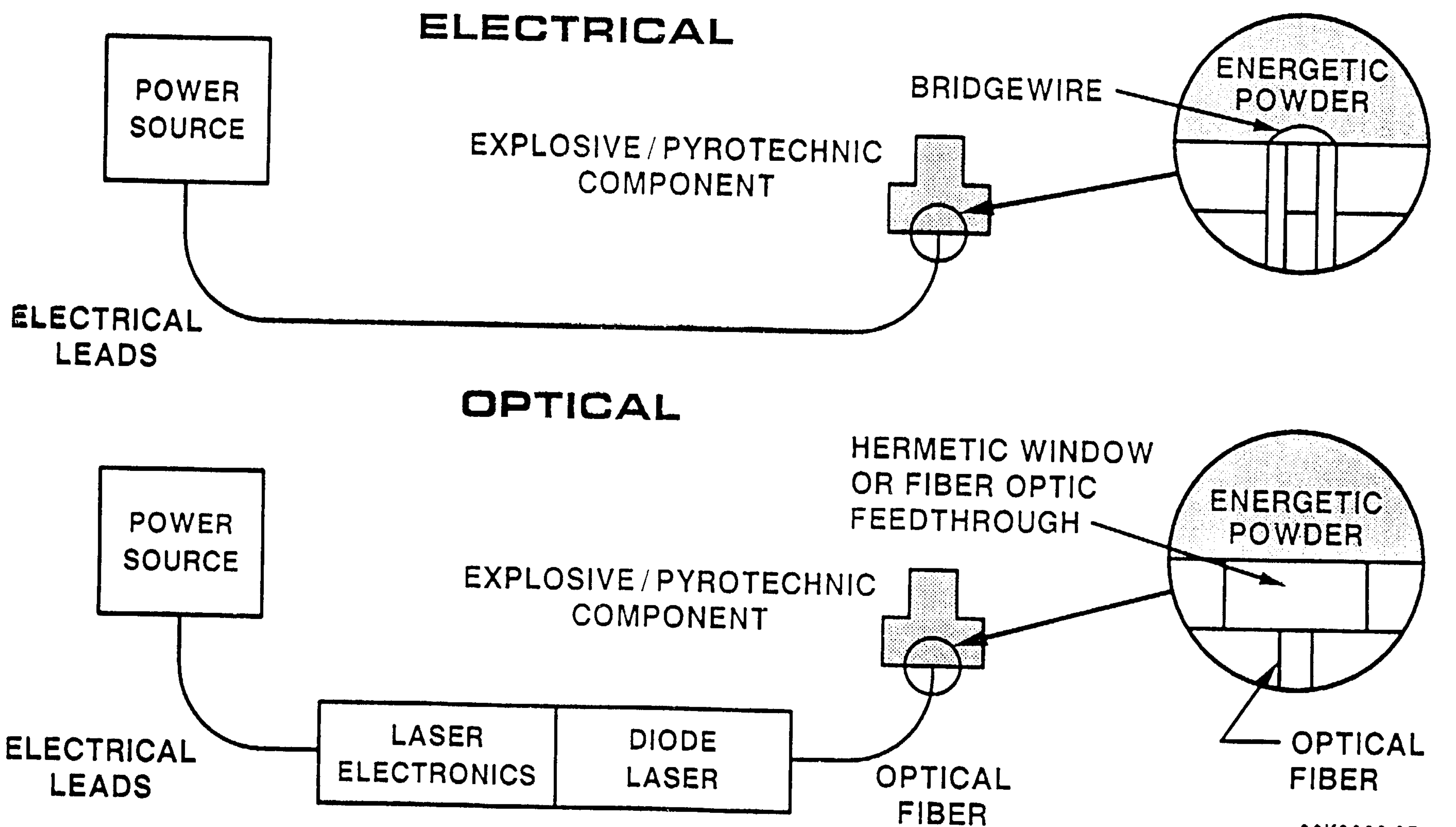
IGNITION SUBSYSTEMS



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R. G. Jungst

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.

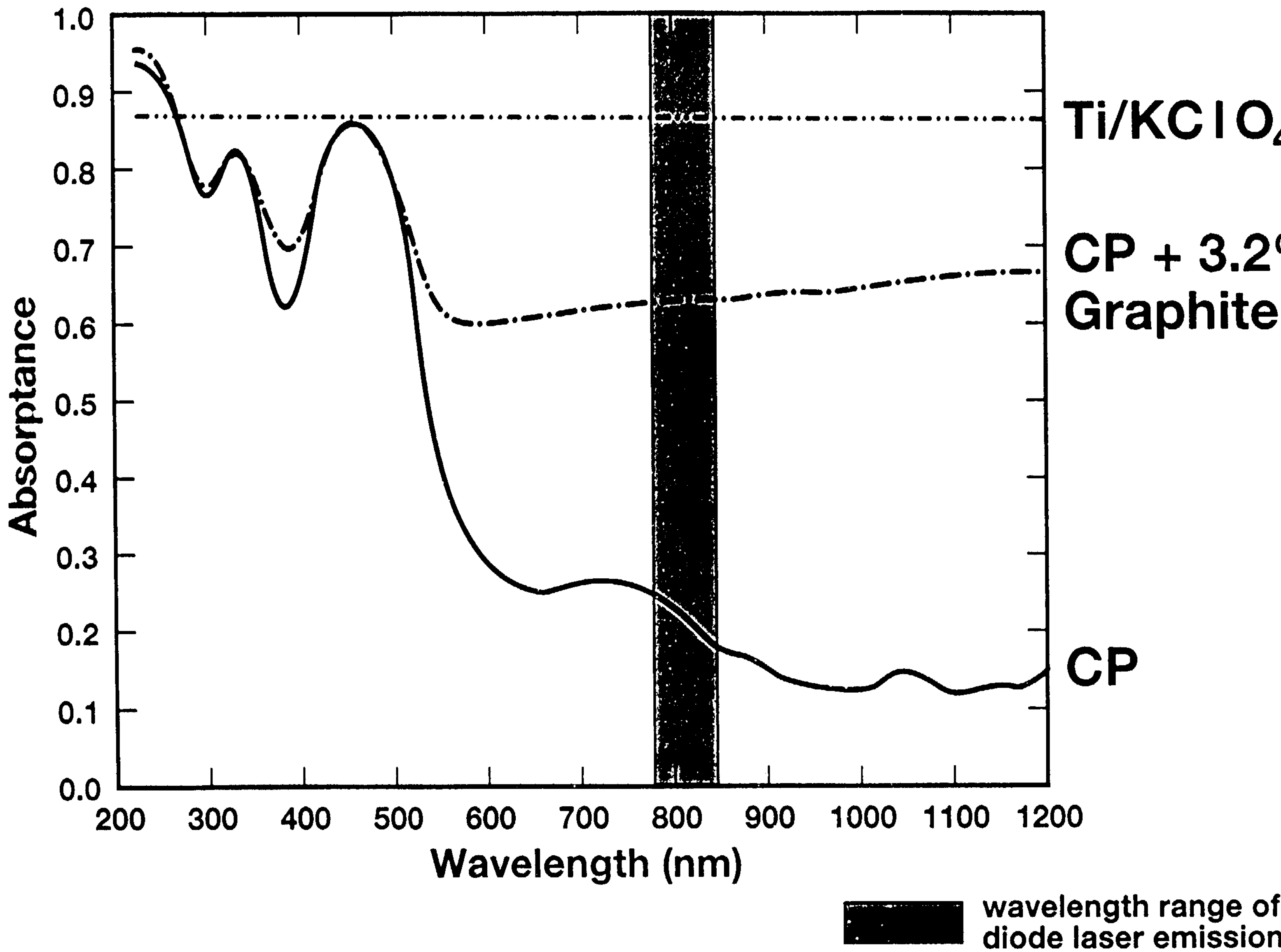
ADVANTAGES: The absence of a bridgewire and electrical leads eliminates powder/bridgewire interface decoupling and corrosion concerns. No fire, CAF, ESD, EMR, and IR concerns are reduced.

Input energy required is comparable to hot wire devices.

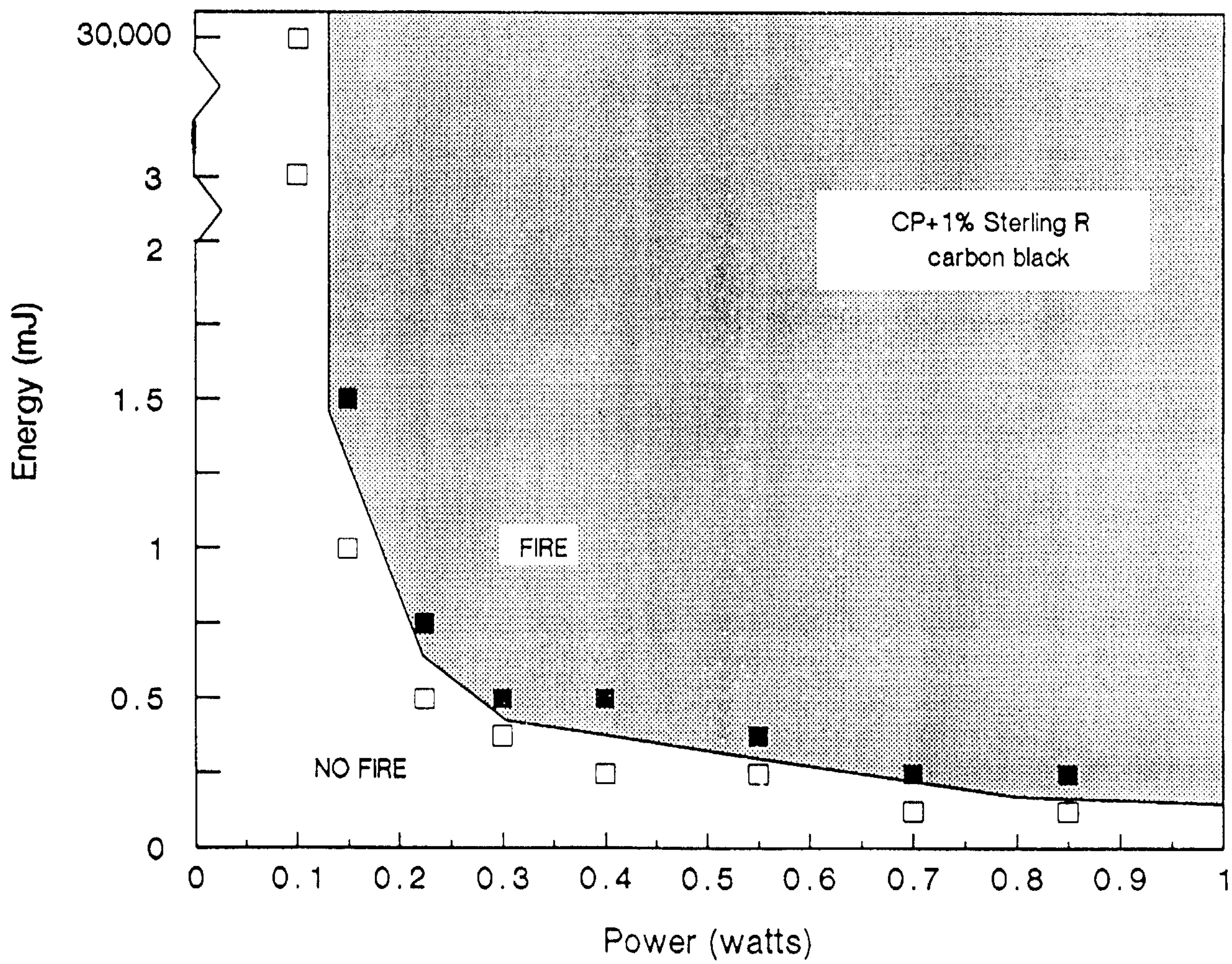
OPTICAL IGNITION FACTORS

- 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



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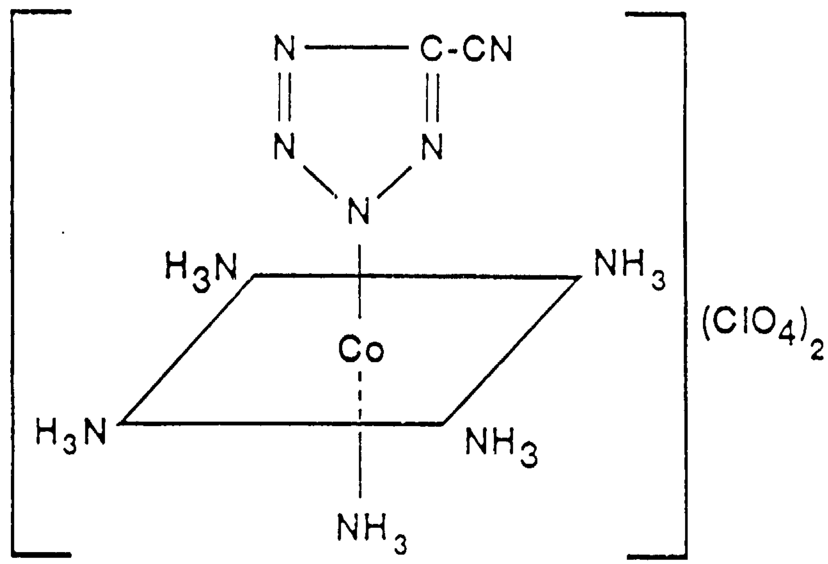
System Operational Electrical Requirements

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 -- $Ti/KClO_4$	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 -- $Ti/KClO_4$	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

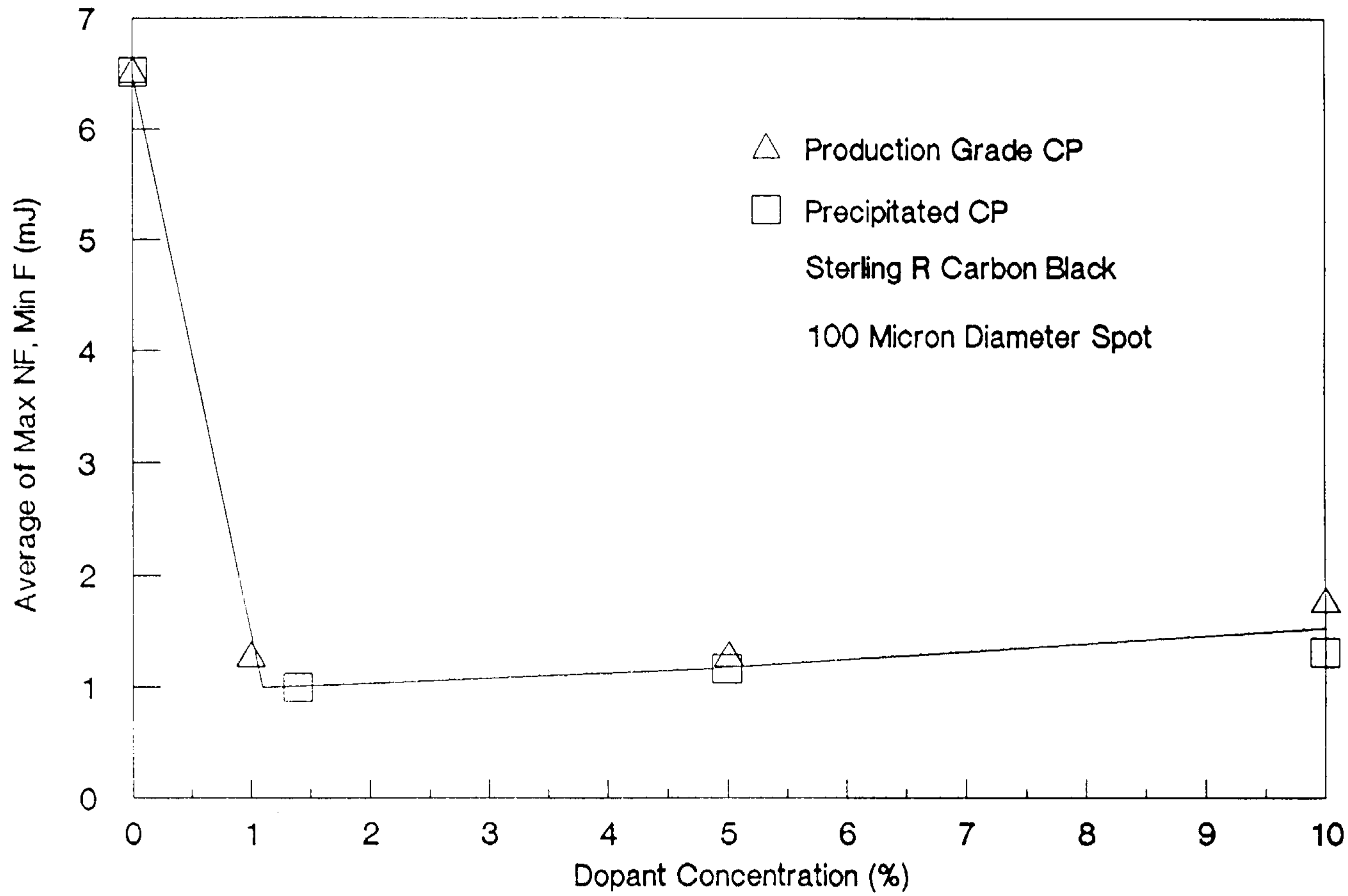


2-(5-cyanotetrazolato)pentaamminecobalt(III) perchlorate (CP)

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

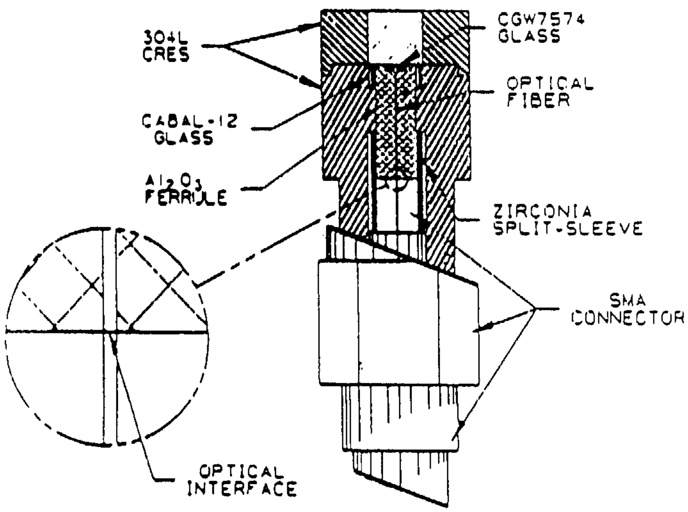
Header Type	Energy Levels	Results
Sealed Fiber Header	1.8/3.0 mJ	No Fire/Fire

Powder--CP/1% Carbon Black

Typical Threshold at Ambient is 1.25 – 1.50 mJ

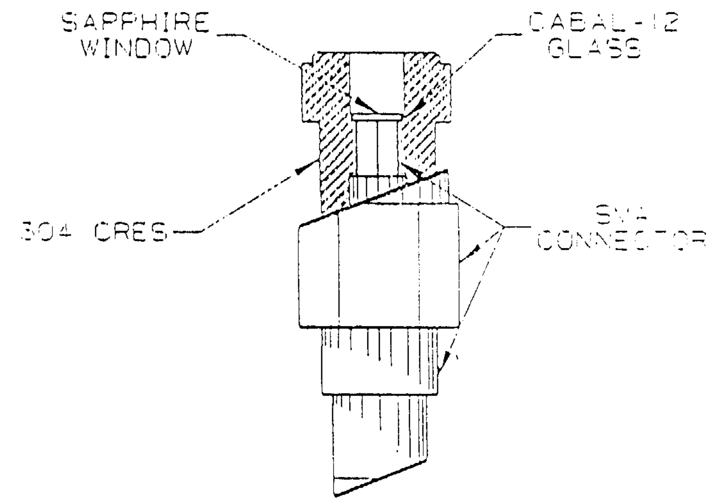
Electrostatic Discharge Testing

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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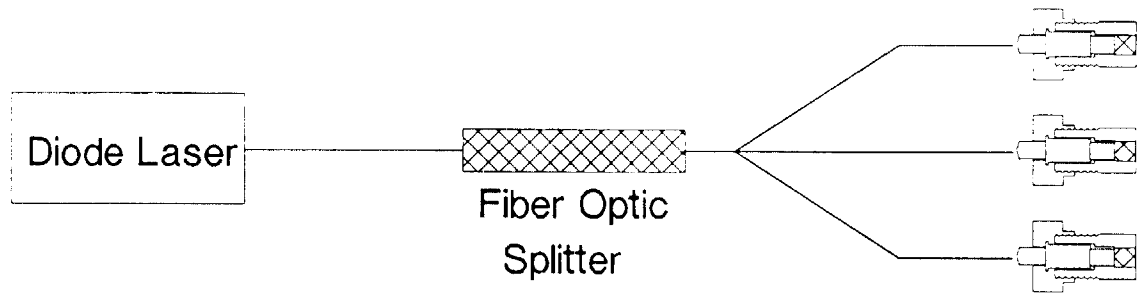
Laser Diode Ignition of 3 ea. Devices

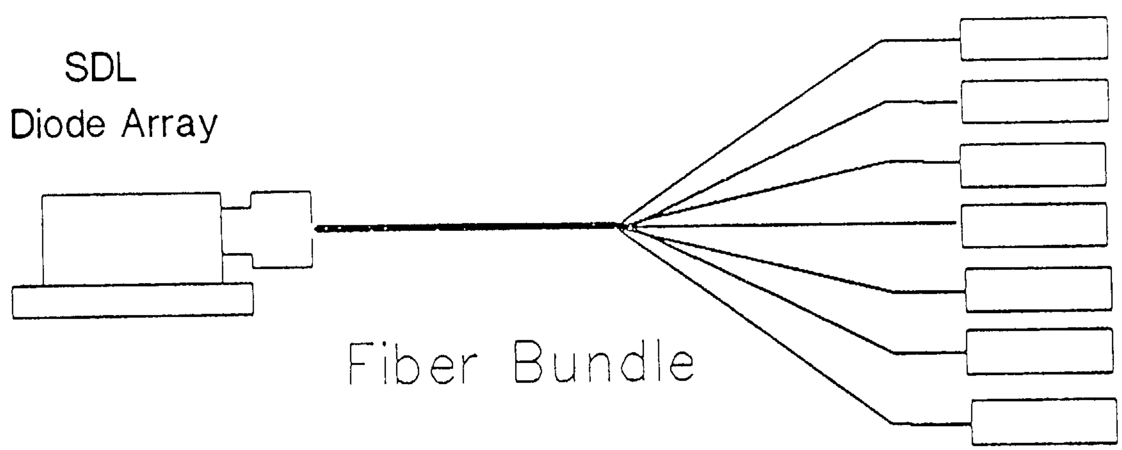


Leg	Energy Level (mj)	Function Time (ms)
1	2.13	1.63
2	2.08	1.80
3	2.03	.892

- 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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