TTL-RH
RADIATION HARDENED LIGHTING

ENGINEERED FOR EXTREME GAMMA & NEUTRON ENVIRONMENTS

TTLGS-2 & TTLGS-1 FUSED SILICA WINDOWS

WITH -OH • HIGH PURITY • EXTREME RADIATION RESISTANCE

HIGH PURITY FUSED SILICA WITH -OH (SILANOL)

TTLGS windows are made from ultra-high purity synthetic fused silica (SiO_2) with controlled high -OH (silanol) content.

- High -OH (≡Si–OH) provides hydrogen passivation to suppress radiation-induced color centers.
- Amorphous SiO_2 network delivers superior tolerance to atomic displacement damage from neutrons.
- Extremely low metallic impurities minimize color-center precursors.
- Excellent optical transmission from UV to visible and IR.

HYDROGEN PASSIVATION TECHNOLOGY

HYDROGEN PASSIVATION MECHANISM

-OH (silanol) groups in fused silica provide hydrogen that passivates dangling bonds created by gamma irradiation, reducing defect centers And improving optical stability.

TTLGS-2 HIGH PERFORMANCE RADIATION WINDOW

Ultra-High Purity Fused Silica with High -OH

QUALIFICATION (TESTED)

GAMMA RADIATION (Co-60 / Cs-137)	NEUTRON FLUENCE (1 MeV equivalent in Si)
1,000 kGy (1 MGy)	4.46×10^{14} n/cm^2

- Outstanding resistance to coloration and darkening
- Maintains high optical transmittance
- Excellent thermal & mechanical stability
- Lead-free & RoHS compliant

TTLGS-1 EXTREME PERFORMANCE RADIATION WINDOW

Ultra-High Purity Fused Silica with High -OH

QUALIFICATION (TESTED)

GAMMA RADIATION (Co-60 / Cs-137)	NEUTRON FLUENCE (1 MeV equivalent in Si)
2,000 kGy (2 MGy)	1.0×10^{16} n/cm^2

ZERO COLOR CHANGE
(100% TRANSMITTANCE RETAINED)

- Extreme resistance to radiation-induced darkening – No color change at 2,000 kGy
- Superior tolerance to neutron-induced displacement damage
- High optical transmission across full spectrum (UV – Visible – IR)
- Lead-free & RoHS compliant

RADIATION PERFORMANCE (Co-60, Room Temperature)

POLYCARBONATE (PC)

0 kGy | 10 kGy | 50 kGy | 100 kGy | 200 kGy

YELLOW → BROWN → DARK BROWN / BLACK
(Sensitive to gamma radiation)

PMMA (ACRYLIC)

0 kGy | 50 kGy | 100 kGy | 150 kGy | 200 kGy

LIGHT YELLOW → AMBER → BROWN
(Moderate resistance)

FUSED SILICA (TTLGS-1)

0 kGy | 500 kGy | 1,000 KGy | 1,500 KGy | 2,000 KGy

NO COLOR CHANGE – 100% TRANSMITTANCE RETAINED
(Excellent resistance)

Actual results depend on dose rate, tempersture, stmosphere, and material thickness.

KEY ADVANTAGES OF TTLGS WINDOWS

EXTREME RESISTANCE
Engineered for the most demanding gamma and neutron environments.

-OH (SILANOL) PASSIVATION
Hydrogen passivation reduces defect centers and darkening.

HIGH PURITY SiO_2
Ultra-high purity and low impurities minimize color center precursors.

AMORPHOUS STRUCTURE
Superior tolerance to atomic diaplacement damage from neutrons.

OPTICAL EXCELLENCE
High transmission from UV to visble to IR with low absorption.

LEAD-FREE & SUSTAINABLE
Environmentally friendly and lower decommissioning cost.

TYPICAL APPLICATIONS

- HOT CELLS & VIEWPORTS
- NUCLEAR POWER PLANTS
- FUEL CYCLE FACILITIES
- ACCELERATORS & RESEARCH
- RADIOPHARMACEUTICAL PRODUCTION
- DEFENSE & NAVAL APPLICATIONS

ParagonLED

Light, for a Safer World

TESTED TO THE LIMIT.

TTL-RH® RADIATION HARDENED LIGHTING

500W MODEL

ENGINEERED FOR THE WORLD'S MOST DEMANDING NUCLEAR ENVIRONMENTS

>1,000 kGy
GAMMA TESTED
(1 MGy)

4.46×10^{14} n/cm^2
NEUTRON TESTED

DRIVERLESS AC LED
ZERO IN-RUSH CURRENT

LEAD-FREE TUNGSTEN-FREE
COBALT-FREE
LOW DECOM COST

BUILT TO ENDURE
ZERO IN-RUSH
DURABLE

COMPLETE RADIATION HARDENED LIGHTING SOLUTIONS
35W TO 500W

VISIT US AT

NECX 2026

BOOTH #
151

LEARN MORE

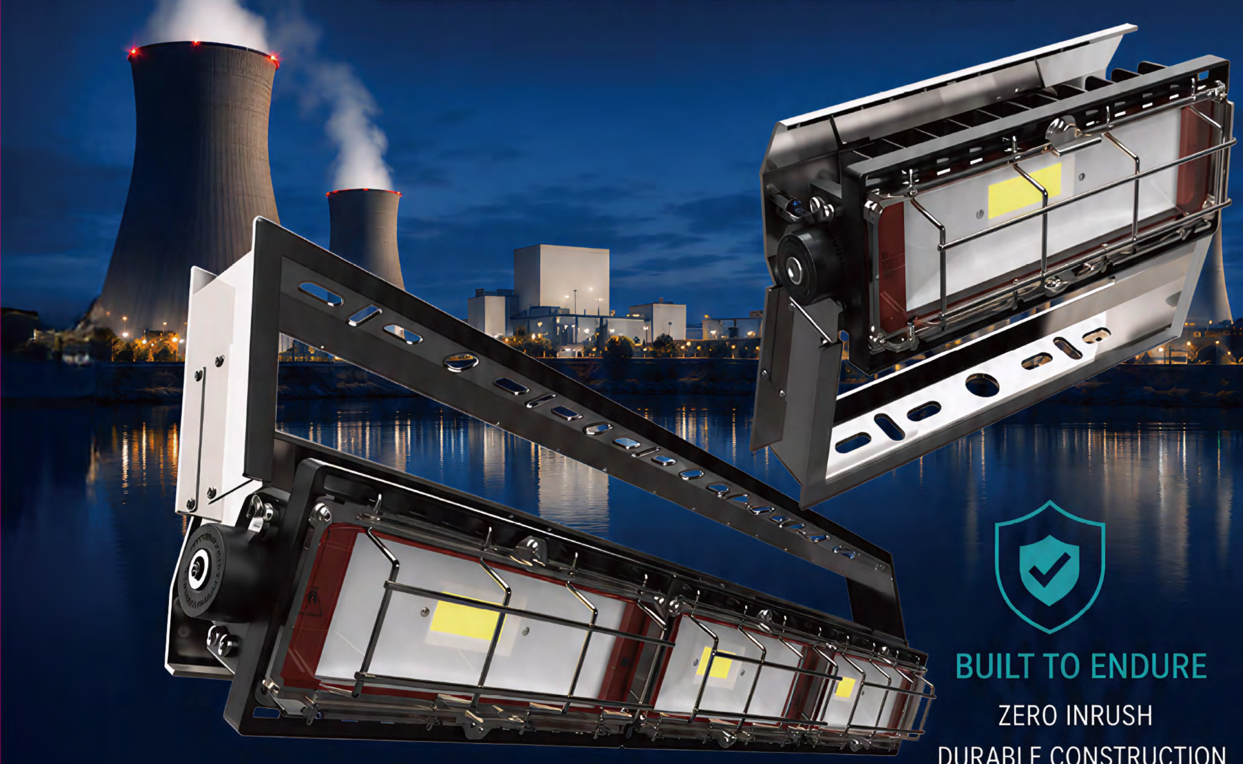
ParagonLED®

Light for a Safer World

TESTED TO THE LIMIT.

TTL-RH™ RADIATION HARDENED LIGHTING

35W MODULAR LED LIGHT



BUILT TO ENDURE

ZERO INRUSH

DURABLE CONSTRUCTION

ENGINEERED FOR THE WORLD'S MOST DEMANDING NUCLEAR ENVIRONMENTS

>1,000 kGy GAMMA TESTED (1 MGy)	4.46×10^{14} n/cm^2 NEUTRON TESTED	DRIVERLESS AC LED ZERO INRUSH CURRENT	LEAD-FREE TUNGSTEN-FREE COBALT-FREE LOW DECOM COST	EXTREME TEMP. -80°C TO +115°C

LEARN MORE

MODULAR • RELIABLE • MAINTENANCE-FRIENDLY

DESIGNED FOR CONTINUOUS PERFORMANCE IN HIGH-RADIATION ZONES

IDEAL FOR NUCLEAR & INDUSTRIAL APPLICATIONS

NUCLEAR POWER PLANTS

HOT CELLS

DRY STORAGE / FUEL POOLS

RESEARCH REACTORS

ACCELERATORS

RADIOPHARMACEUTICAL FACILITIES

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AUGUST 24–27, 2026

Hilton Anatole

Dallas, Texas, USA

thermal-tech-lighting.com

ACCOB LIGHT ENGINE EVOLUTION

Flip Chip Technology for High Temperature, Gamma Radiation and Fast Neutron Environments

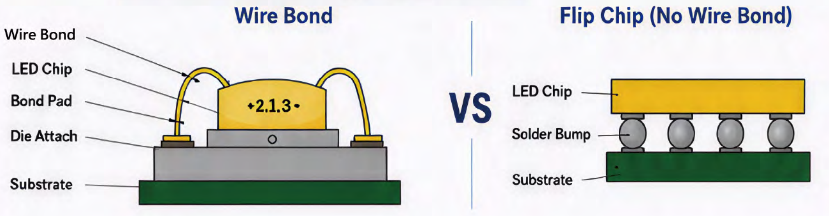
Industrial LED Technology → Extreme Environment → Radiation Hardened Platform → Nuclear Applications

1 LIGHT ENGINE EVOLUTION

Traditional Wire Bond → Flip Chip (No Wire Bond) → ACCOB → Driverless ACCOB → Radiation Hardened ACCOB → TTL-RH Platform

WIRE BOND vs FLIP CHIP

Wire Bond VS Flip Chip (No Wire Bond)



- ✓ No wire bond – no fatigue
- ✓ Lower thermal resistance
- ✓ Better heat dissipation
- ✓ Higher reliability
- ✓ Lower EMI
- ✓ Longer life

2 WHY FLIP CHIP?

NO WIRE BOND	BETTER THERMAL PATH	LOWER THERMAL RESISTANCE	UNIFORM CURRENT	LONGER LM80 LIFE	LOWER EMI
No bond fatigue No break risk	Heat flows directly to substrate	Reduce 20–50% thermal resistance	Current spreads evenly more uniform brightness	Lower Tj Longer LM80 life	Lower inductance Lower EMI noise

3 EVOLUTION TOWARD NUCLEAR

Industrial → Steel Mill → Chemical Plant → Mining → Nuclear → Radiopharma · Hot Cell → Research Reactor · DOE · Nuclear Power Plant → Future Military Platform

INDUSTRIAL ENVIRONMENTS — NUCLEAR & EXTREME ENVIRONMENTS

4 RADIATION HARDENED ACCOB PLATFORM

TRADITIONAL LED ARCHITECTURE

- ✗ Wire Bond
- ✗ MOSFET Driver
- ✗ Organic PCB
- ✗ High Frequency Switching
- ✗ Multiple Failure Points

VS

TTL-RH ACCOB ARCHITECTURE

- ✓ Flip Chip
- ✓ Driverless (120 Hz AC)
- ✓ No Wire Bond
- ✓ Simplified Architecture
- ✓ High Reliability

DRIVERLESS ACCOB ARCHITECTURE

ZERO INRUSH
INSTANT ON
HIGH SURVIVABILITY

5 RADIATION TEST RESULTS

GAMMA (Co-60)

TESTED	TARGET (IN PROGRESS)
1,000 kGy (>1 MGy TID)	2,000 kGy

FAST NEUTRON (1–14 MeV)

TESTED	TARGET (IN PROGRESS)
4.46×10^{14} n/cm² (1 MeV Equivalent, Si)	1×10^{16} n/cm²

Testing conducted at NARI (Taiwan) . On Bias 6kGy / hour Gamma Facility . Fast Neutron: TR 30/15

6 CERAMIC DPC (DPC/Ceramic Substrate) vs. METAL CORE PCB (MCPCB)

FEATURES	CERAMIC DPC (DPC / Ceramic Subatrate)	METAL CORE PCB (MCPCB)
Dielectric Layer	✓ No Organic Dielectric	✗ Organic Dielectric (insulating Layer)
Gamma Radiation (TID)	✓ Excellent (>1,000 kGy)	✗ Moderate to Poor (Dielectric Dependent)
Fast Neutron Resistance	✓ Excellent (>1012n/cm³)	✗ Moderate to Poor (Dielectric Dependent)
Delamination Risk	✓ No Delamination Risk	✗ Possible Delamination
Thermal Conductivity	✓ High (24–170 W/m-K)	○ Good (2–5 W/m-K) via Al Core
Best For	✓ Extreme Radiation, Nuclear, Space, Military	○ General Lighting, Medium Conditions

Ceramic DPC eliminates the dielectric weak point found in conventional MCPCB designs.

7 WHY RADIATION SURVIVABILITY?

GAMMA RADIATION — Causes TID and component degredation
+ **FAST NEUTRON** — Causes displacement damage and fallures
+ **HIGH TEMPERATURE** — Up to 125°C continuous operation
+ **VIBRATION & SHOCK** — Mechanical stress and fatigue

→ **ONE LIGHT ENGINE BUILT TO SURVIVE EXTREME ENVIRONMENTS**

8 APPLICATIONS

Hot Cell Lighting · Radiopharma Facilities · Research Reactors · DOE Facilities · Nuclear Power Plants · Industrial Plants · Marine & Naval Platforms · Future Military Systems

9 TESTED TO THE LIMIT

Built for the World's Most Demanding Environments

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TTL touch the limit

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