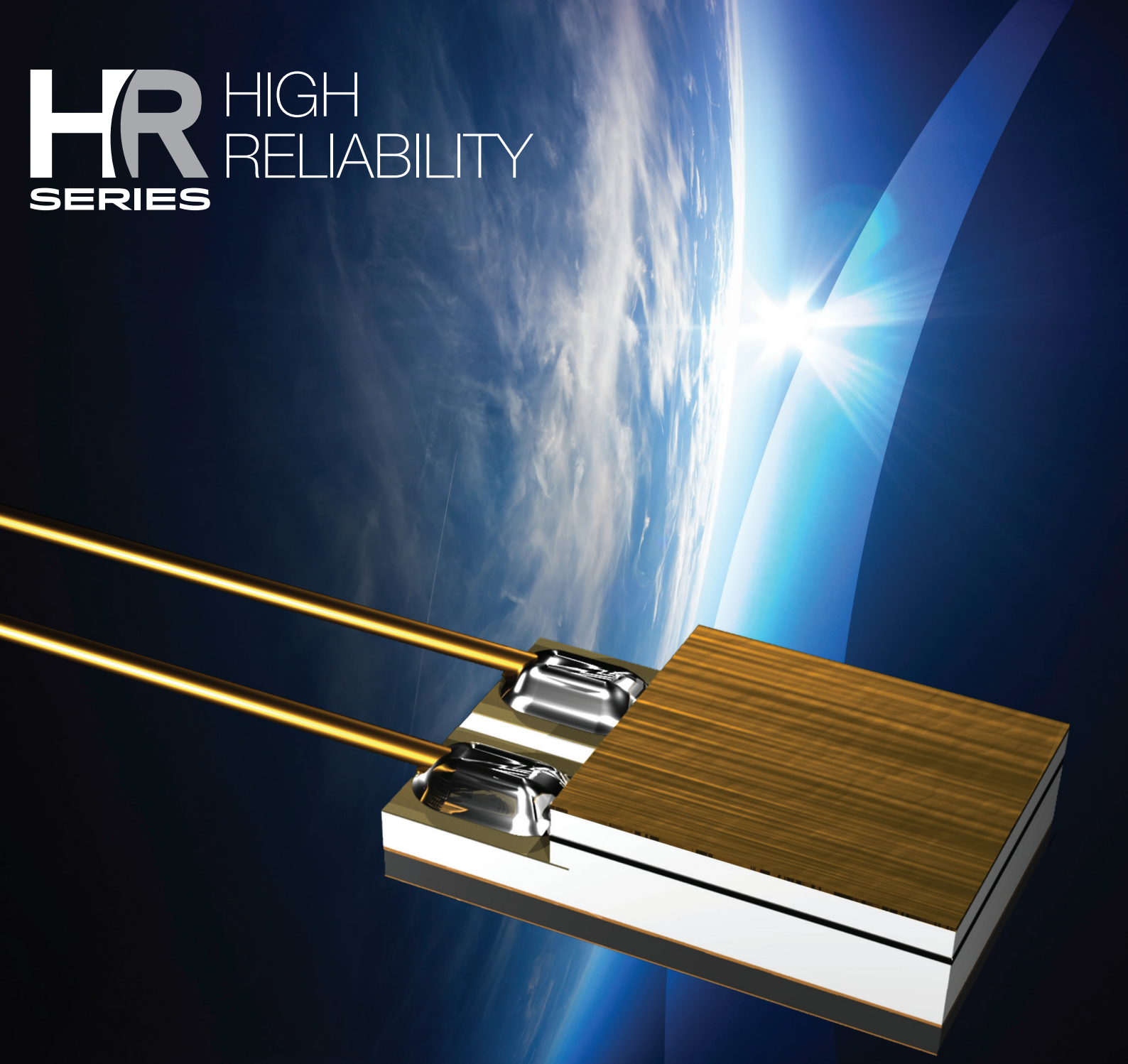
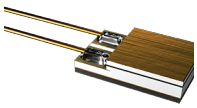
# HR SERIES HIGH RELIABILITY



High reliability Cernox® sensors for mission-critical applications

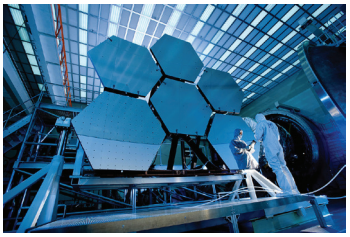
Lake Shore CRYOTRONICS

## HR Series sensors



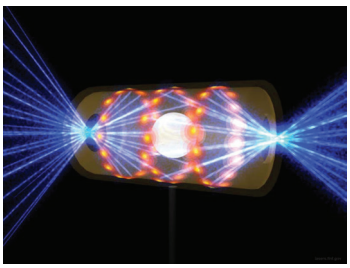
The HR Series is a new line of high reliability cryogenic temperature sensors for mission-critical applications. Starting with our proven Cernox® temperature sensor technology, we have developed a family of off-the-shelf sensors that have already undergone extreme testing steps to assure you of extra reliability.

- Full material traceability for 15 years
- Resistance and sensitivity data available for all sensors
- Reduces lead time
- Gain confidence from our test protocol
- No hidden costs—pay only for the sensors you buy



## For when the best needs to be better

In situations where cryogenic temperature control or monitoring forms a critical component of a system and the cost of sensor failure far exceeds the cost of the sensor, subjecting sensors to a higher level of scrutiny becomes vital. Projects where outcomes are worth far more than the sum of their parts are prime examples of this and include:



- Space telescopes
- Supercolliders
- Fusion reactors
- Research satellites
- Maglev locomotives

## Reduce risk on critical projects

### On time

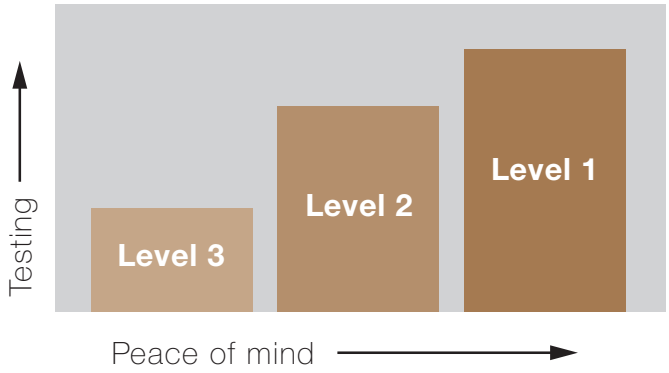
Following standardized testing procedures, these sensors are built on regular production schedules and stocked for rapid delivery, resulting in lead times comparable to standard commercial sensors. Predefined testing protocol also cuts paperwork—no need to define different detailed sensor requirements for every program.

### On budget

Traditionally, sensor procurement for critical programs required that additional sensors for destructive qualification tests be purchased for each lot, increasing the total cost to the project without increasing the number of sensors that are available to install. Cernox HR sensors are different. Lake Shore performs the qualification testing for each lot, with the resulting screening and qualification test report being supplied at no additional cost to sensor buyers. With HR sensors, you only pay for the sensors that you use.

## Scalable levels of testing

Due to the unique nature of projects, the level of testing and verification required for each project will change. To accommodate this, various degrees of testing and verification are available in the HR Series product line. This ranges from Level 3 sensors that undergo a limited subset of acceptance screening tests to Level 1 sensors which are fully screened and qualified for the highest confidence level possible. This allows sensors to be selected that are appropriately qualified for the application.



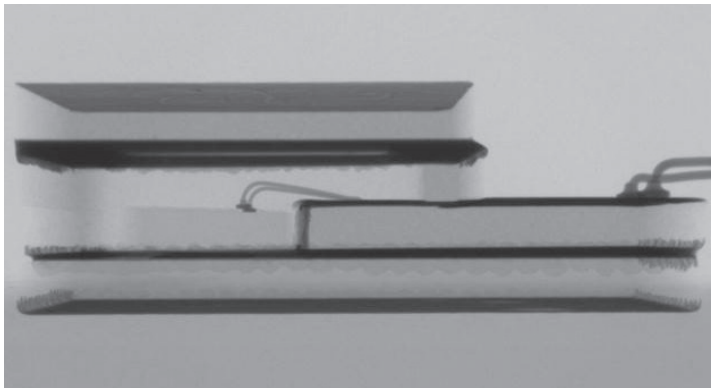
## Test types—how we ensure sensor performance and quality control

### Acceptance screening

100% of Cernox® HR sensors undergo screening that:

- Weeds out sensors that may experience early-life failures
- Eliminates sensors that exhibit minor or major defects that might one day cause a failure to occur
- Identifies defects and failures without exposing sensors to stresses that would merely weaken them

For a full list of tests performed see page 4.



*Lake Shore x-rays each sensor to verify the quality of the die attachment and to ensure sufficient clearance between the internal wires and lid.*

### Qualification testing

A sample group is tested to verify that all sensors in a manufactured lot are fit for service. They are put through punishing and stressful testing scenarios to verify the sensors' ability to survive in these conditions. Destructive analysis is also performed on some sensors to verify the quality of components at the completion of screening.

#### Independent destructive physical analysis

- Internal gas analysis
- Die shear strength
- Wire bond pull strength

#### Vibration and mechanical shock

Highly stressful physical test of the product's ruggedness.

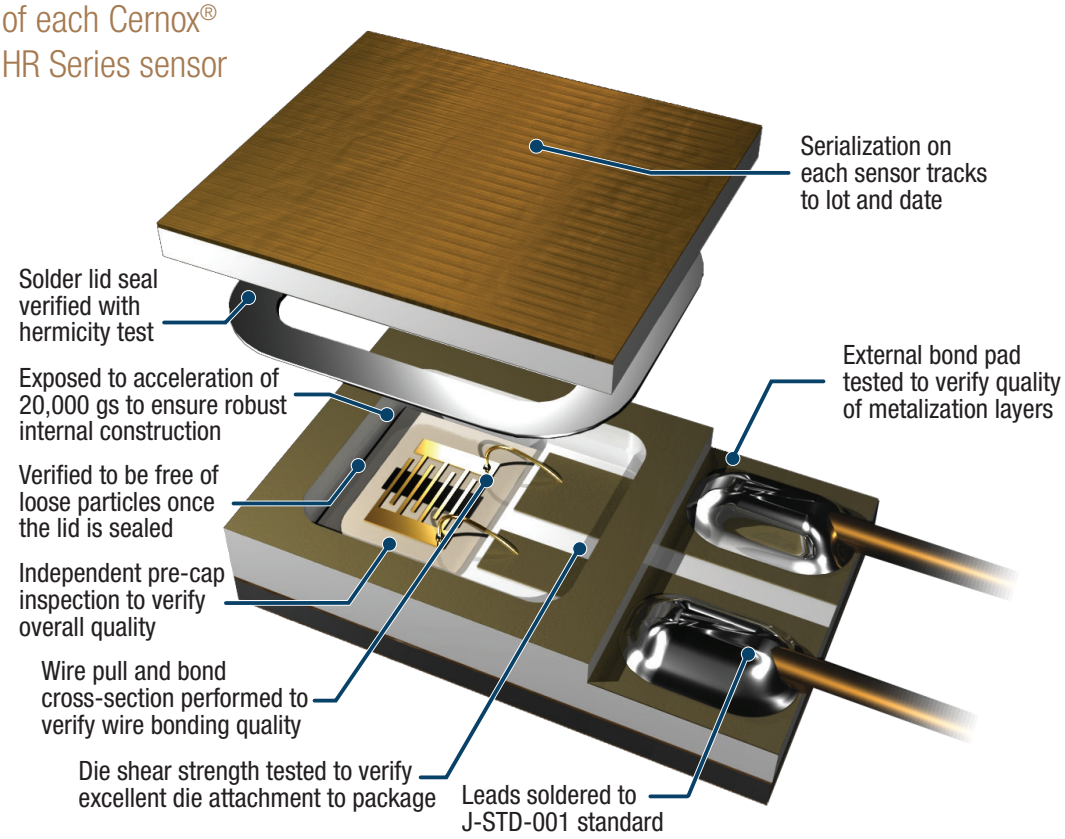
#### Outgassing

Destructive analysis to ensure that materials that many contaminate nearby components are not present on the sensor.

#### Life test

Accelerated life test involving 2,000 hours at maximum rated temperature to ensure survivability even under punishing conditions.

## We test every part of each Cernox® HR Series sensor




## Other verification steps include:

- Thermal shock conditioning and stabilization bake to settle the sensor into a stable temperature curve
- Sensors are exposed to one week of continuous operation at elevated temperatures, then exposed to 100 thermal shocks between room temperature and liquid nitrogen (77.35 K) to weed out early-life failures
- Sensor inspected for any visual defects at various stages of production

# HR SERIES HIGH RELIABILITY

## For your mission-critical research

Space is undoubtedly a challenging environment for any electronic component. The success of any mission depends upon the reliability of the discrete components that must be able to operate in extreme cold, in vacuum, and under excessive radiation—not to mention the ability to survive the shock, vibration, and acceleration of launch. Failure of a single component can result in the failure of an entire mission.

For two decades, Lake Shore has worked with a number of aerospace entities, supplying thermometry that offers long-term stability and performance over the duration of a mission. These include hundreds of flight-qualified sensors for the NASA James Webb Space Telescope and sensors for the Mars Curiosity rover.

Because we are highly familiar with the unique challenges of measuring temperature in space, we understand what it takes to design for long-term thermometry stability and reliability, particularly when measuring at the very low end of the temperature scale, where thermal, magnetic, and electrical interactions can heavily influence reading accuracy.

## Test protocols include:

**Acceptance Steps**

- Full lot traceability for a minimum of 15 years
- Independent inspection of sensor before sealing
- Constant acceleration (20,000 *g*s)
- Particle impact noise detection (PIND) test
- X-ray (internal defects and wire clearance)
- Burn-in (1 week)
- Thermal cycling (repeated between 298 and 4.2 K)
- Fine hermetic seal
- Gross hermetic seal
- Visual inspection to MIL standards

**Qualification tests**

- Die shear strength
- Wire bond strength
- Wire bond cross section
- External bond pad bondability
- Independent destructive physical analysis
- Outgassing
- Thermal shock (100 shocks)
- Vibration testing
- Mechanical shock
- Life test (up to 2,000 h)

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