ADVANCED & VERSATILE LITHIUM ION BATTERY SOLUTION

FOR MARINE/SUBMARINE INDUSTRY

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DEPLOYMENT OF MORE THAN 50 MWh WITH KOKAM LITHIUM ION BATTERY TECHNOLOGY IN MARINE & SUBMARINE INDUSTRY
As a globally acknowledged battery manufacturer and battery solution provider, Kokam has developed customer-centered, reliable, safe, high performing, and eco-friendly solution for the past 28 years. Kokam manufactures over 30 different types of Lithium Ion batteries for variety of military applications such as Fighter Jets, Armed Fighting & Support Vehicles, Mobile Energy Storage Systems(ESS), and Portable Devices. Kokam battery has pioneered applications in Unmanned Aviation and Ground Vehicles(UAV & UGV), and Unmanned Underwater Vehicles(UUV). With 28 years of field experience, Kokam has installed over 650MWh of batteries around the world. Kokam’s technology has been proven to be high performing, reliable, durable, and safe.

<table>
<thead>
<tr>
<th>A LITHIUM ION BATTERY THAT MEETS YOUR APPLICATION’S NEEDS</th>
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<tbody>
<tr>
<td>UAV / DRONE / FIGHTER JET:</td>
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<tr>
<td>UAVs are controlled from ground-based stations. Such advanced vehicles require advanced sensory, communication and power components to ensure a safe and reliable flight. Installing high tech components into a relatively small UAV is often impractical. However compact features of Lithium Ion battery allows additional space within the UAVs, which could be used to accommodate various components. The Lithium Ion battery is the most safe and quiet power source for UAV’s.</td>
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<td>ARMED FIGHTING &amp; SUPPORT VEHICLE:</td>
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<tr>
<td>High energy density, high power and light weight Lithium Ion battery improves the mobility of wheeled vehicles. More military transport, combat, and unmanned vehicles are turning toward fully electrical or hybrid systems where the battery becomes the primary source of power propulsion.</td>
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<tr>
<td>UUV / TORPEDO / SUBMARINE:</td>
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<tr>
<td>Lithium Ion battery is the best source of power for UUV, Torpedo and Submarine. Its compact design brings higher efficiency and strengthens reliability for diverse marine application.</td>
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<tr>
<td>MOBILE ESS:</td>
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<tr>
<td>Kokam’s Mobile ESS provides sufficient energy for various devices in the battlefield. Compared to the conventional diesel generator, it releases less noise and heat, allowing for more efficient energy supply.</td>
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<tr>
<td>PORTABLE DEVICE / COMMUNICATION TOWER:</td>
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<tr>
<td>Batteries are installed in various types of military communication equipments, providing reliable power under harsh conditions at critical times. The same technology is used for emergency power support in telecom stations and control facilities.</td>
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650 MWh                      Since 1989                      
Accumulated installation     Established KOKAM
KOKAM LITHIUM ION CELL

“TRANSCEND THE LIMITATIONS WITH THE FUSION OF SUPERIOR CELL CHEMISTRY”

Kokam sets about to solve the limitations associated with conventional Lithium Ion Battery technology, including cycle and calendar life, safety, recharge time, power delivery, and ability to operate in extreme temperatures. The performance and features of this technology surpass other existing battery capabilities in the market space today.

**HIGH POWER**
- 100 C-rate

**HIGH ENERGY DENSITY**
- 260 Wh/kg

**OPERATING TEMPERATURE**
- -30 ~ 60 degC

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**CELL CHEMISTRY**

**HIGH ENERGY NMC (NICKEL MANGANESE COBALT)**

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<thead>
<tr>
<th>Advantages</th>
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<tbody>
<tr>
<td>- High energy density (~ 260Wh/kg): Up to 2.8MWh of batteries can be stored in a 40ft container</td>
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<tr>
<td>- High efficiency of more than 96% at 0.5C</td>
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<tr>
<td>- Competitive Price: The NMC cells have a comparative advantage in terms of price, considering its superior performance, reliability and safety features.</td>
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**HIGH POWER NMC**

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<td>- High C-rate up to 100 C-rate level</td>
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<tr>
<td>- High C-rate discharge performance for uses in laser weapon, torpedo, etc.</td>
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<tr>
<td>- Improved performance without safety or cycle life trade off</td>
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**LITHIUM TITANATE (LTO)**

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<tr>
<td>- Operating temperature: -30 ~ 60 degC.</td>
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<tr>
<td>- High specific power: 4 C-rate continuous and 8 C-rate peak charge &amp; discharge operation</td>
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<tr>
<td>- High round trip efficiency (RTE): &gt;95%.</td>
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<tr>
<td>- Long cycle life: 20,000 cycles @ 80% DoD, 1C charge &amp; discharge operating conditions.</td>
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<tr>
<td>- Extremely Safe: A thermal runaway event is significantly less likely to occur in LTO cells. LTO cells can also be re-operated after an event of an over-discharge, unlike conventional graphite based Li-Ion cells. This feature enables the user to operate the battery cells under extreme environmental and usage conditions.</td>
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<td>- Advantages of the LTO cells: Anode side of ordinary Li-Ion cells are made up of graphite, the anode side of the LTO cell is composed of Lithium Titanate, which has stronger chemical structure than graphite.</td>
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**NMC + LFP+LTO (NANO)**

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<td>- Specially designed for defense &amp; aerospace application</td>
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<tr>
<td>- This hybrid type cell has incorporated the advantages of NMC, LFP and LTO cells into one cell. It is suitable for extremely volatile and dynamic operational conditions. The high power, energy and safety features allow the NANO cells to be flexibly applied in various applications.</td>
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LITHIUM ION BATTERY SYSTEMS FOR MARINE ESS
DESIGNED FOR EXTREME SAFETY & RELIABILITY

SPECIFICATION
- 70Ah Nano HP cells, 2P20S
- 74VDC and 10.36kWh capacity
- 3P continuous charging rate
- 5P continuous discharging rate

EXTREMELY SAFE BATTERY SYSTEMS.
Kokam has developed water cooled Lithium Ion Battery suitable for the marine applications which require extreme safety and reliability under harsh ocean environment. It provides peak shaving capability against momentary high energy burst to enable commercial vessels or offshore supporting vessels to save fuel and extend the life of main engines or generators. Additionally, this module can be used for inland vehicles like trucks, buses and trams which require high maneuverability and regeneration absorbing capability.

KEY FEATURES
- Direct water cooling with water jacket inserted between the cells
- IP56 and salinity resistive housing
- Easy change of module length according to the customer requirement
- Thermal runaway tested according to classification society rules
- Shock, vibration, temperature, EMI/EMC, Salinity tested according to classification society rules
- Ship Roll and Pitch tested according to submarine/ship motion requirement

APPLICATIONS
- Hybrid Electric System in commercial and offshore vessels
- Electric Propulsion System

MILITARY LITHIUM ION BATTERY SYSTEMS FOR HIGH-PERFORMANCE
ONE OF THE WORLD’S MOST POWERFUL BATTERY SOLUTIONS

SCALABLE, VALIDATED, READY FOR USE. HIGH-PERFORMANCE BATTERY SYSTEMS.
- Freely scaleable system design
- Extremely Compact & Light Weight Solution
- Easy to Scale-Up & Ready to connect
- Stable Temperature with Liquid Cooling System
- Thermal Management for Long Service Life
- Optimum Production System resulting in excellent Price Performance ratio
- Monitoring of Voltage and Temperature
- SOC/SOH analysis
- Voltage balancing between the modules

LIQUID COOLED BATTERY SYSTEM
1. Cell
2. Module
3. High-strength battery tray
4. Thermal insulation
5. Coolant connection
6. Coolant connector
7. Electric connection
8. Main contactor box
9. High voltage connection
10. BMS
11. Safety control unit

DESIGNED WITH MILITARY STANDARDS
With its flexible and modular design, Kokam’s Battery Module can be customized to meet various technical needs. Reliability of batteries in military, marine and aviation is vital to its performance. Kokam’s Lithium Polymer batteries are capable of operating over a wide temperature range, which is ideal for rugged military use. Kokam provides high-tech solution for various military applications ranging from small portable electronics to highly sophisticated machinery, ensuring that it is always prepared for the unexpected.
Kokam's battery maximizes the performance of electric boats. With its high energy density, Kokam provides battery solutions which are significantly smaller in size and weigh less than competitive products. In addition, Kokam batteries' outstanding power output is favorable as a starting power source that cranks the engine with a momentary high power burst.

Scandlines Hybrid Ferry Project
- Solution: Integrated with Kokam battery technology
- Application: Marine propulsion
- Capacity: 2.7MWh
- Characteristics
  - World's largest hybrid passenger ferry
  - Can propel the 15,000-tonne ship for about 30 minutes without diesel fuel
SAFETY CENTERED
- Intrinsic safety of cell chemistry
- Smart short circuit protection
- Heat and electric insulation packaging system

UNPRECEDENTED LONGEVITY
- More than a decade of life proven at sea
- Extremely lower capacity fading rate
- The world’s lowest internal resistance

PROVEN RELIABILITY
- More than a decade of fault-free recorded operation
- LBTS durance & abuse tested
- US MIL-STD certified

FULL CUSTOMIZATION SERVICE
- Chemical tuning for the best optimization
- Scalability of hardware and software
- Full in-house design and production

SUBMARINE
DEPLOYMENT OF LITHIUM ION BATTERY POWER STRATEGIC ADVANTAGE
Advanced technology in Lithium Ion battery is enabling strategic advantages in marine applications. The battery has high energy density both in weight and volume, coupled with the capacity to rapidly charge and discharge, delivering immense amounts of power over many thousands of cycles with minimum degradation. Compared to the lead acid batteries, the Lithium Ion battery delivers higher amounts of stored energy and power.

Kokam is a world market in the field of Lithium Ion battery for maritime applications. Examples of large scale deployment of Kokam Lithium Ion battery include, electric propulsion of surface ships (100% battery powered ferries with displacement of up to 3000 tonnes); hybrid ship propulsion to reduce fuel consumption and boost peak power, thus reducing reliance on gas turbines and propulsion of diesel electric submarines with the strategic advantages of increased sub surface range, higher speed, and reduced surface charge time.

As with all technology deployments, safe operation requires a fully engineered solution. In addition, selecting the most suitable technology for each application is imperative for a successful deployment.

For example, the propelling characteristic of a torpedo is remarkably different compared to that of a submarine. Kokam offers customized cells that are best suitable for specific applications.

Kokam ensures the safety of the cells by selecting the appropriate chemical ingredients and adopting rigorous quality management procedures. That is why Kokam has over 10 years of incident-free deployment of Lithium Ion cells in marine applications such as the UUVs, submarines, and torpedoes.
Kokam’s high-performance lithium polymer battery technology delivers high power and energy density combined with excellent safety performance and cycle life.

**ENERGY:**
Higher usable energy means greater battery utilization and lower cost.

**POWER:**
Superior power by weight or volume in a cost effective solution.

**CYCLE:**
Excellent calendar and cycle life with consistent performance over extended use.