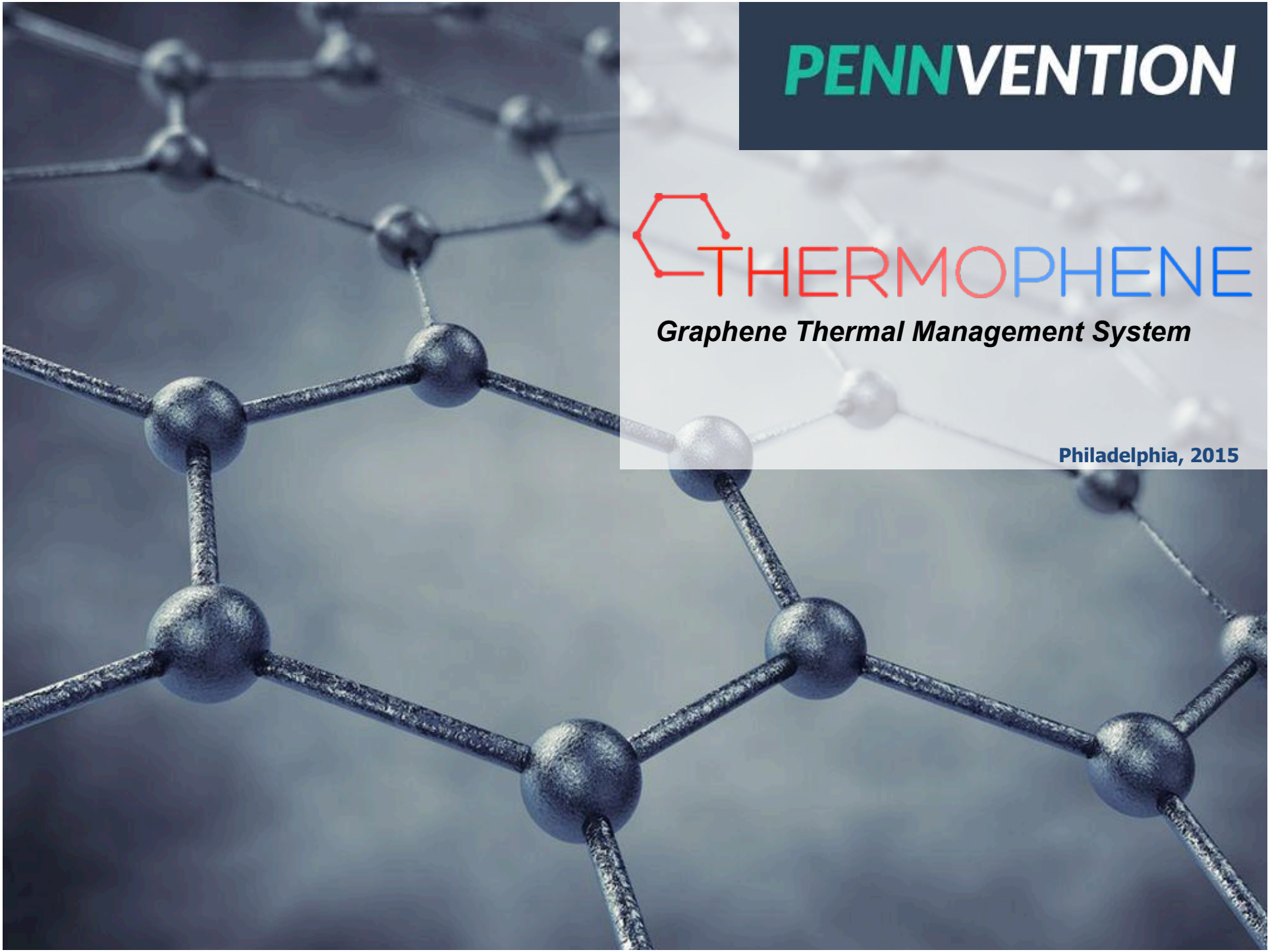


PENNVENTION

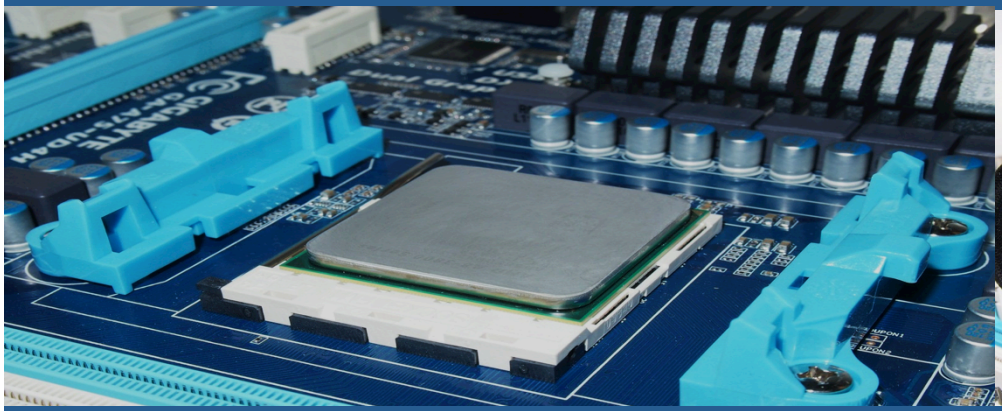
THERMOPHENE

Graphene Thermal Management System

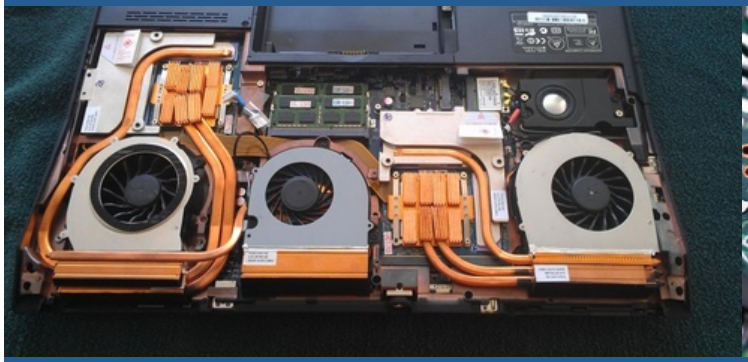
Philadelphia, 2015

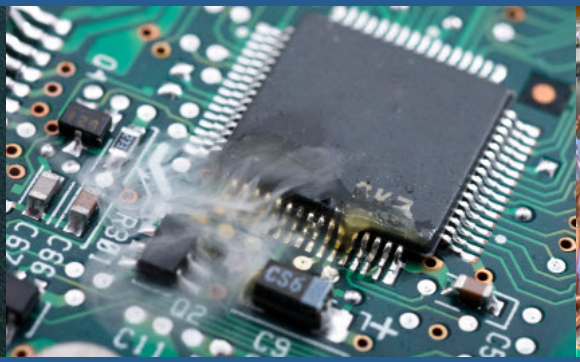
THERMOPHENE

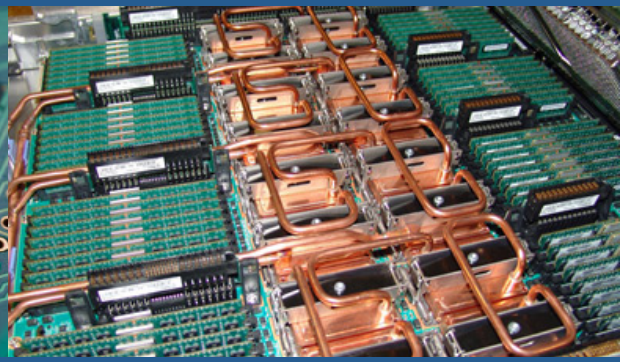
Elevated operating temperature causes 55% of all electronic failure



Current thermal management systems create not only a bottleneck on electronics' performance and innovation but also complexity to the hardware design with cumbersome size and weight





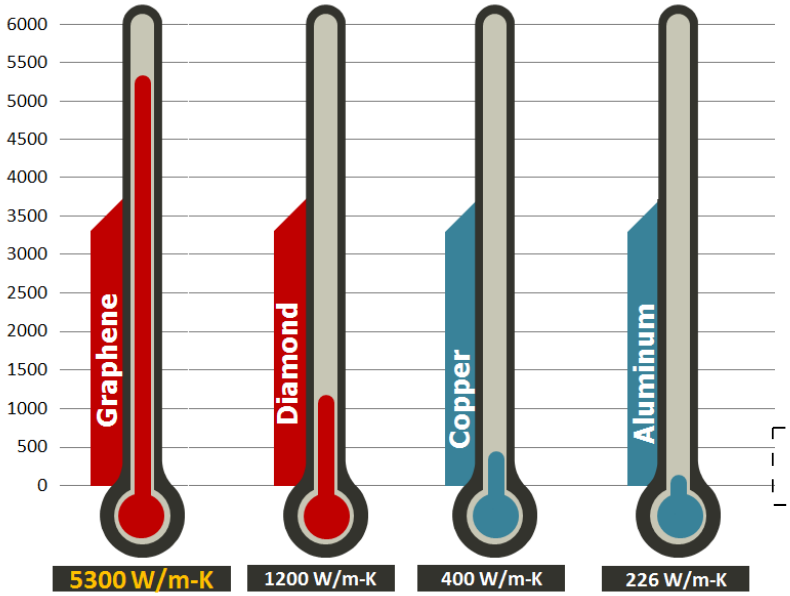


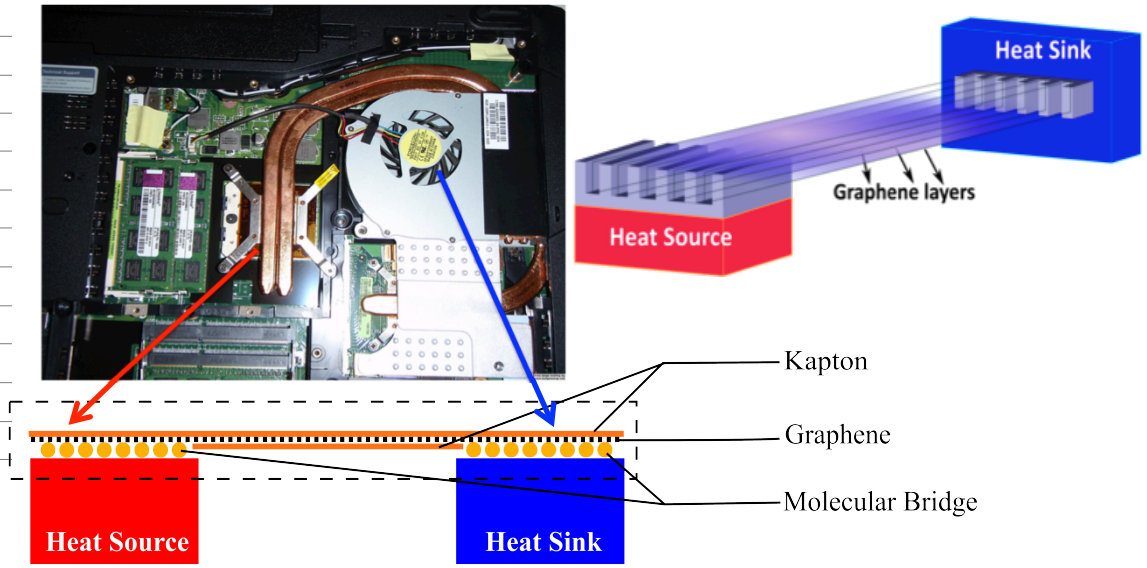
Thermophene creates a new universe for hardware design and electronics's innovation as it gives manufacturers independence from thermal constraints by employing the thermal conductivity, and 2D structure of graphene in the next-generation of high-efficiency thermal management systems

02 Product

THERMOPHENE

Graphene advantage lies on its ***extremely high thermal conductivity*** against other market competitors, including diamond, which outperforms by a factor of 5x. Graphene's ***light weight*** and ***2D structure***, allows for flexible applications providing better design and performance to the electronics manufacturers





Thermophene thermal management system design

A. Thermal interface material: This employs efficient ***molecular bridges*** between metallic contacts at the heat source and at the heat sink with the graphene. We will optimize the organic ligand that significantly reduces the interfacial thermal resistance by ensuring the graphene-substrate direct chemical contact.

B. Device coating: Our model consists of ***graphene sheets*** implemented as a two-dimensional (*xy*) ***heat transfer tape*** from the heat source to the heat sink. To ensure its high performance a ***thermal insulator material (Kapton)*** is needed to protect the graphene heat tape from its environment and vice versa.

C. Device architecture: To overcome graphene's poor *z*-axis thermal conductivity. Several iterations of product design will be employed and enriched by pilot studies to optimize the ***device architecture*** within the electronic platform.

THERMOPHENE

Growing market opportunity of $3B

Characteristic of target market

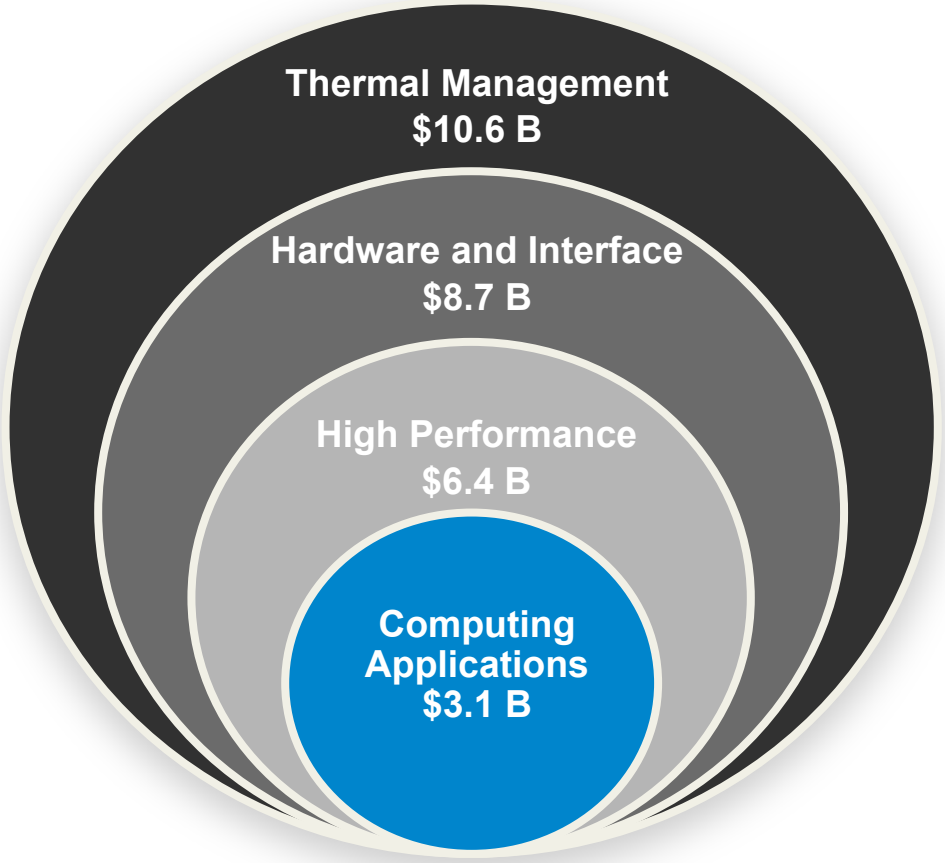
- Lifespan/performance reduced by operating temperature.
- Conductive heat transfer issues
- High performance applications
- Cost efficient solution
- High reliability systems

Entry Markets

Servers

Laptops

Desktops



The team has conducted primary research for market validation:

"Replacing the copper heat pipes with your technology will provide space, better design, and even better production-quality ratio"

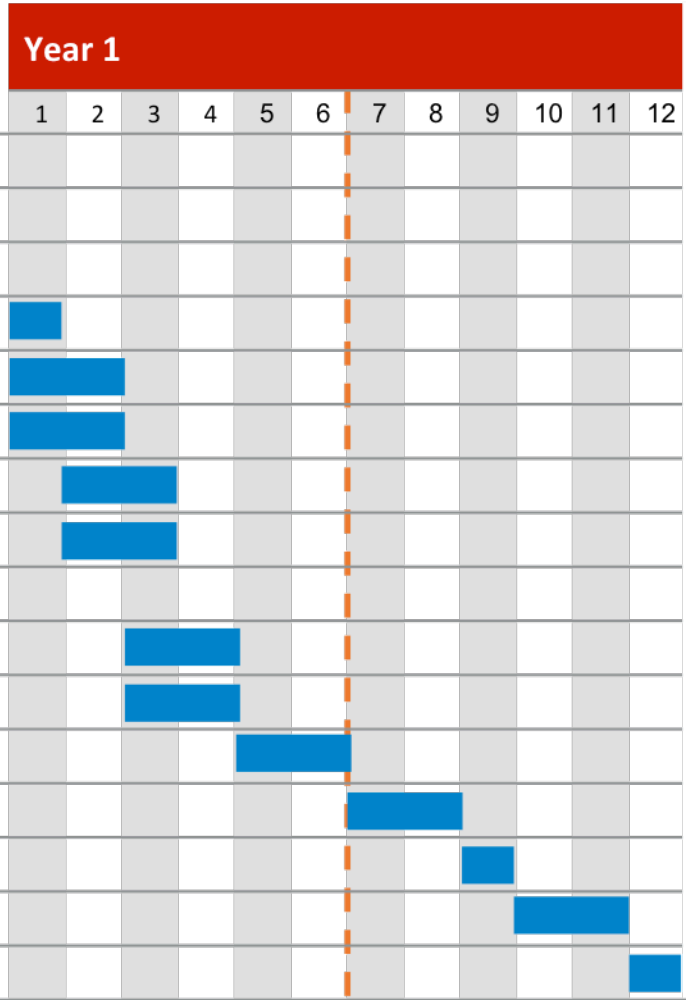
Francisco Pinto – Procurement Engineer @ Lenovo

The electronic industry severely suffers from overheating as the thermal management systems have not evolved at the same rate as modern electronics. Current thermal management system provide a limited solution to the amount of heat dissipated by electronics

04 Development Plan

THERMOPHENE

Our technical development follows the Technology readiness level (TRL). First 6-months: testing device components to reach a functional prototype. The first product is delivered at the end of the cycle.



TRL 1	**Basic principles observed and reported – COMPLETED**
TRL 2	**Technology concept and/or application formulated – COMPLETED**
TRL 3	**Analytical and experimental critical function and/or characteristic proof of concept**
TRL 3.1	Identify molecular bridges parameters and architecture guidelines to meet
TRL 3.2	Research on Existing Patents and Labs identifying key partnerships
TRL 3.3	Lab Heat Tests over 1 Layer of Graphene device
TRL 3.4	Lab Heat Tests over Multiple Layers of Graphene device
TRL 3.5	Iterate over Interface and Insulator materials
TRL 4	**Component and/or breadboard validation in laboratory environment**
TRL 4.1	Interface contacts - Graphene and Contact Materials
TRL 4.2	Heat Transfer – Layered Graphene and Insulating Materials are tested
TRL 5	**First functional prototype is developed**
TRL 6	**First Prototype is Tested in Laboratory Environment**
TRL 7	**Prototype demonstration in an operational environment.**
TRL 8	**Final prototype is completed and qualified through test and demonstration.**
TRL 9	**First product is tested in successful operations over working products**

The expected development cost over the next 6 months will be **$7500-10000**, including renting lab space and equipment. It incorporates the cost of the device's components: graphene manufacturing, interfacial and insulating materials, testing devices, among others. We'll leverage to have reached the **Y-Prize Grand Finale** to establish partnerships with research groups at Penn.

The estimated cost per thermophene unit is **$70**, assuming a multilayer-device at a graphene's production cost of $2/cm^2, which is expected to decrease as more technologies adopt graphene as their key material.

05 Team

Diomedes Saldana
CEO

Leads the strategic scientific and business operations

PhD Candidate Theoretical Physical Chemistry

Research expertise on 2D materials

Software and web-based startup experience

Bernardo Herrero
COO

Oversees the technological development as well as the business front

MS Candidate Systems Engineering

Project Manager *Odebrecht*

Project Engineer *ABB*

Weiyang Lim
CTO

Advances the technological and engineering implementation of the devices

MS Candidate Nanotechnology

Research expertise on MEMS and polymeric coating

Jing Yang
CSO

Develops research directions on optimizing thermal performance of the device

PhD Candidate Theoretical Physical Chemistry

Research expertise on nanoscale materials

Team Strenghts: A total of 12 years of Research and Development, 3 years in startups experience, and 8 years of industrial and project managment experiencie and leadership.

Networks and Leverage: One to one contact with experts in graphene research and thermal managment systems.

Skill sets required in the future: Graphene and nanotecnology manufacturing expertise, finance, sales and marketing strategy in electronics industry.