The Future of Automotive Semiconductors
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Speaker Profile

DAVID POH
Founder, Spiral Group Sdn. Bhd.

An engineer by training, David began his career as an engineer in the telecommunications industry for 10 years before turning to his passion in value investing. He served as a Director in a local equities education and research firm for 3 years, managing research efforts and delivering advanced value investing and portfolio management education series. Thereafter, he stepped out to pursue his own aspirations, establishing the Spiral Thinker Group - a collaborative alliance to promote intelligent value investing and develop algorithm-based adaptive portfolio strategies for sustainable, long term wealth creation. David is now a full-time investor and dedicates his time and resources to nurture the youth in financial literacy. He is often invited to speak in brokers’ seminars, webinars as well as other BURSA-endorsed events, and his professional comments and opinions on value investing are featured in business publications like FOCUS MALAYSIA. David also provides consultation services in value investing and advanced portfolio strategies for high net worth individuals.

fb.me/fixpressmy
AGENDA

THE FUTURE OF AUTOMOTIVE SEMICONDUCTORS

• Future Trends in Automotive Industry
• Paradigm Shift in Automotive Electronics
• 3 Key Growth Automotive Segments
• Major US Automotive Electronics Suppliers
• Case Studies on Bursa Companies
FUTURE TRENDS IN AUTOMOTIVE INDUSTRY

5G (and Beyond) Serves as the Bedrock of Future Technologies

Source: Semiconductors – the Next Wave, Deloitte
FUTURE TRENDS IN AUTOMOTIVE INDUSTRY

Electrification is Inevitable in Modern Transportation Systems

Image Sources:
historic-uk.com | waldorflibrary.org | thepublicpurpose.com | railwaygazette.com | en.wikipedia.org | copper.org | vectorstock.com
FUTURE TRENDS IN AUTOMOTIVE INDUSTRY

A Global Climate Imperative: Net-Zero Emissions by 2050

The United Nations body for assessing the science related to climate change

Special Report in 2018 on Global Warming of 1.5 °C, known as SR15, following request after the Paris Agreement in 2015

- To stabilize global temperatures at 1.5°C above pre-industrial levels and reducing the devastating health and economic impacts of the climate crisis.
- To achieve net-zero greenhouse gas emissions (GHG) globally by 2050.
- To potentially reduce global road transport emissions to 11.9%, by electrifying the whole road transport sector, and transition to a fully decarbonized electricity mix.
Countries Commitment to Phase Out ICE Vehicles in Favor of EVs

<table>
<thead>
<tr>
<th>Country</th>
<th>Current government proposals to ban ICE only vehicle sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>Actively considering and studying a ban</td>
</tr>
<tr>
<td>France</td>
<td>2040</td>
</tr>
<tr>
<td>Germany</td>
<td>2030</td>
</tr>
<tr>
<td>India</td>
<td>2030</td>
</tr>
<tr>
<td>Ireland</td>
<td>2030</td>
</tr>
<tr>
<td>Israel</td>
<td>2030</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2030</td>
</tr>
<tr>
<td>Norway</td>
<td>2025</td>
</tr>
<tr>
<td>Scotland</td>
<td>2032</td>
</tr>
<tr>
<td>UK</td>
<td>2040</td>
</tr>
</tbody>
</table>

Source: Bloomberg | NEF. Note: Passenger car and bus figures are global. Commercial vehicle segment adoption figures in both charts cover the main markets of China, Europe and the U.S.

Source: Bloomberg New Energy Finance

UK to ban sales of new petrol, diesel cars from 2030, 10 years earlier than planned – hybrids go on till 2035

In Cars, International News / By Danny Tan / 17 November 2020 10:52 am / 6 comments

Source: Bloomberg | paultan.org | thomsonreuters.com
Automotive Electrification Requires Higher Semiconductor Content

**2020 average xEV semiconductor content by degree of electrification**

<table>
<thead>
<tr>
<th>48 V / Mild Hybrids</th>
<th>Full &amp; Plug-in Hybrids and Battery Electric Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Power-train*</td>
<td>Non-Power-train*</td>
</tr>
<tr>
<td>$396</td>
<td>$396</td>
</tr>
<tr>
<td>ICE Power-train</td>
<td>ICE Power-train</td>
</tr>
<tr>
<td>$61</td>
<td>$38</td>
</tr>
<tr>
<td>xEV Sensors</td>
<td>xEV Sensors</td>
</tr>
<tr>
<td>$7</td>
<td>$14</td>
</tr>
<tr>
<td>xEV MCUs</td>
<td>xEV MCUs</td>
</tr>
<tr>
<td>$17</td>
<td>$23</td>
</tr>
<tr>
<td>xEV Power**</td>
<td>xEV Power**</td>
</tr>
<tr>
<td>$90</td>
<td>$330</td>
</tr>
<tr>
<td>xEV Others**</td>
<td>xEV Others**</td>
</tr>
<tr>
<td>$0</td>
<td>$32</td>
</tr>
<tr>
<td>Total semi BoM</td>
<td>Total semi BoM</td>
</tr>
<tr>
<td>$572</td>
<td>$834</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Vehicles</th>
<th>2020</th>
<th>2022</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2.1m</td>
<td>5.8m</td>
<td>18.8m</td>
<td>27.3m</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>5.8m</td>
<td>12.2m</td>
<td>21.0m</td>
<td>32.0m</td>
</tr>
</tbody>
</table>

*Non-Powertrain: average semiconductor content in body, chassis, safety and infotainment application segments
**Power* includes voltage regulators and ASIC; *others* include opto, small signal discretes, memory

Source: Infineon; based on or includes content supplied by IHS Markit, Automotive Group: Alternative Propulsion Forecast, July 2020;
Strategy Analytics: Automotive Semiconductor Demand Forecast 2018-2027 and Automotive Sensor Demand 2018-2027, July 2020

“Power” : includes voltage regulators and ASIC  
“Others” : includes opto, small signal discretes, memory

Source : Infineon.com
PARADIGM SHIFT IN AUTOMOTIVE ELECTRONICS

Trending From Higher Automation to Mobility as a Service

AUTOMATION LEVELS OF AUTONOMOUS CARS

LEVEL 0
There are no autonomous features.

LEVEL 1
These cars can handle one task at a time, like automatic braking.

LEVEL 2
These cars would have at least two automated functions.

LEVEL 3
These cars handle “dynamic driving tasks” but might still need intervention.

LEVEL 4
These cars are officially driverless in certain environments.

LEVEL 5
These cars can operate entirely on their own without any driver presence.

SOURCE: SAE International

Source: businessinsider.com | investors.nxp.com
PARADIGM SHIFT IN AUTOMOTIVE ELECTRONICS

Higher Levels of Automation Requires Higher Semiconductor Content

The need for dependable systems per degree of automation

Increasing degree of automation...

- Level 0: No System
- Level 1: Foot-off
- Level 2: Hands-off
- Level 3: Eyes-off
- Level 4: Brains-off
- Level 5: No Driver

...requires dependable systems

Dependable Sensing + Dependable Computing + Secure Communication + Dependable Actuation + Dependable Power Supply + Dependable Memory

Incremental average semiconductor content per car by level of automation at the given years

- **Level 2**: L2 vehicles in 2020: ~5m
  - Bill-of-materials: $160 - $180
  - Camera modules: 40 - 50% of BoM
  - Radar & Lidar modules: ~30%
  - Sensor fusion: 20 - 30%
  - Others (e.g. actuators): 5 - 10%

- **Level 2+**: L2+ in 2025: ~2.5m
  - Bill-of-materials: $280 - $350
  - Camera modules: 40 - 50% of BoM
  - Radar & Lidar modules: ~30%
  - Sensor fusion: 20 - 30%
  - Others (e.g. actuators): 5 - 10%

- **Level 4/L5**: L4/L5 vehicles in 2030: ~2.5m
  - Bill-of-materials: $1,150 - $1,250
  - Camera modules: 15 - 20% of BoM
  - Radar & Lidar modules: 30 - 45%
  - Sensor fusion: 30 - 45%
  - Others (e.g. actuators): 5 - 10%

Source: Infineon.com
PARADIGM SHIFT IN AUTOMOTIVE ELECTRONICS

Higher Levels of Automation Require Higher Semiconductor Content

GLOBAL SEMICONDUCTOR BILLINGS & GROWTH

Compiled from various PwC reports on Global Semiconductor Outlook
3 KEY GROWTH AUTOMOTIVE SEGMENTS

Electrification, Infotainment and Autonomous Mobility Lead the Way

Source: ALPHA Research @ Spiral Thinker Group
3 KEY GROWTH AUTOMOTIVE SEGMENTS

Power Electronics Growth Potential by Segments

2019-2025 power electronics market evolution and its main segments
(Source: Status of the Power Electronics Industry 2020 report, Yole Développement, 2020)

Source : yole.fr
MAJOR AUTOMOTIVE ELECTRONICS SUPPLIERS

Power Discrete Supplier Ranking

2019 Main power discrete and modules suppliers in $M

(Source: Status of the Power Electronics Industry 2020 report, Yole Développement, 2020)

- Infineon Technologies
- ON Semiconductor
- STMicroelectronics
- Vishay Intertechnology
- Mitsubishi
- ROHM Semiconductor
- Toshiba
- Renesas
- Fuji Electric
- Littelfuse
- Diodes
- Semikron
- Nexperia
- Alpha and Omega Semiconductor
- Bosch

Source: yole.fr
3 KEY GROWTH AUTOMOTIVE SEGMENTS

Power Components for Vehicle Electrification

A LEADER IN VEHICLE ELECTRIFICATION

ON-BOARD CHARGER
- 650 V SJ MOSFETs
- 650 V Si/SiC Rectifiers/FETs
- Automotive HV modules
- Gate drivers
- 650 V IGBTs
- 650 V GaN transistors
- Op-amps & current sense
- DC-DC, LDO, IVN, ASIC

MAIN DRIVE
- 650/1200 V Rectifiers
- 1200 V SiC Rectifiers/FETs
- 650/1200 V IGBTs
- 650 V GaN transistors
- Op-amps & current sense
- DC-DC, LDO, IVN, ASIC

12V 48V DC-DC
- 80/200 V FETs
- Half-bridge drivers (high speed)
- 40 V FETs
- Op-amps & current sense
- DC-DC, LDO, IVN, ASICs

BATTERY MANAGEMENT
- 40 V FETs (lowest RDSON)

HV LOADS
- 650 V SJ MOSFETs
- 650 V Si/SlC Rectifiers/FETs
- 650 V IGBTs
- Half-bridge drivers
- P-channel MOSFETs
- 650 V GaN transistors
- Automotive modules
- Op-amps & current sense
- DC-DC, LDO, IVN, ASICs

Source: onsemi.com
3 KEY GROWTH AUTOMOTIVE SEGMENTS

MLCC: Most Widely Used Passive Components

- **Powertrains**
  - Engine control devices
  - Engine cooling fans
  - DC/DC converters
  - Transmission control devices
  - Pump control devices

- **Chassis and safety devices**
  - Power steering
  - Airbag control
  - Cameras, radar systems
  - Brake control devices
  - ABS, traction control

- **Interior**
  - Car GPS systems
  - Car audio systems
  - Air conditioning
  - Body control units
  - Instrument clusters
  - Door locks
  - Power seats

- **Exterior**
  - Lights
  - Power wipers
  - Power sliding doors
  - Grille shutters

---

**MLCC COUNT**

- **iPhone 6s (2015)**: 500
- **iPhone X (2018)**: 1,000
- **ICE Vehicles**: 2,500

Source: cirvos.com
3 KEY GROWTH AUTOMOTIVE SEGMENTS

MLCC: Most Widely Used Passive Components

Murata Manufacturing (6981 JP)

Target price: JPY25,000 (as of 19 Jul)
Share price (28 Dec): JPY14,955 | Up/downside: +67.2%

Outperform
(not reviewed)

Ready for a smartphone market slowdown
- Automotive MLCC sales growing on added value from ultra-high reliability
- 5G potential: profit with MetroCirc, pickup in filters/wireless modules
- New growth driver lined up after some birthing pains in FY17

What’s the impact: The number of capacitors per vehicle has risen as automobiles see increased electrical content with more electrically driven systems and the spread of ADAS and self-driving. Components have to be more reliable than ever before, given the need to perform super-computer-like calculations in extremely harsh conditions (high temperatures/pressure). To meet these challenges, Murata is mass producing MLCCs with ultra-high reliability for automotive applications. This is ushering in a completely new source of added value. Sales of automotive MLCC products, which have grown steadily at a CAGR of 16% for FY03-17, are gaining further momentum and are likely to rise at nearly 40% in FY18 with the gains in high-added-value products. While demand for highly reliable MLCCs for automotive applications is likely to keep growing, there are few firms that can mass produce such products, and the barriers to entry are extremely high.

Source: daiwa.com
KLSE : UNISEM (M) BERHAD

Global OSAT and Semiconductor Turnkey Service Provider

Source : Malaysia Tech Sector Teach-In, Alliance DBS Research | CGS-CIMB
KLSE: MALAYSIA PACIFIC INDUSTRIES BERHAD

6th Largest Independent OSAT Subcontractor Globally

Source: Malaysia Tech Sector Teach-In, Alliance DBS Research | CGS-CIMB
### KLSE: PENTAMASTER CORP. BERHAD

**World Class Automation Solutions Provider**

#### SEMICONDUCTOR & MEMS SENSOR
- **Test Solutions**
  - Discrete & ICs
  - Power Device
  - Power Module
  - Motion Sensor
- Automated Vision Inspection Solutions
- Assembly & Process Solutions
  - Laser Marking
  - Laser Cutting & Deburr
  - Customized Solutions
  - Active Alignment
  - Epoxy Dispense/Screwing & Housing Attach

#### OPTICS & PHOTONICS SENSOR
- **Test Solutions**
  - Structured Light 3D Sensor
  - Proximity Sensor
  - Time of Flight 3D Sensor
  - Ambient Light Sensor
  - Image Sensor
  - Spectrum Sensor
  - Wafer-Level VCSEL
  - Diffractive Optical Element & Micro Lens Array
  - Edge Emitting Laser Module
- **LED Burn-In & Test Solution**
  - LED Test & Burn-In Test System
  - LED Burn-In Oven System
  - Constant Current Rack Module

#### FACTORY AUTOMATION SOLUTIONS
- Material Handling Conveyor System
- High Speed Sortation System
- Assembly & Test Modules
- Robotics Technology
- Manufacturing Executive System (MES)
- Intelligent Automated Robotic Manufacturing System (i-ARMS)
- Customized Solutions for Consumer & Electronic Products
- Automated Guided Vehicle (AGV)
- Storage System
- i-Work Bench
- Automated Reel Packer

#### MEDICAL INDUSTRY SOLUTIONS
- Hospital & Nursing Home Equipment
  - Q-Flush (Macerator)
  - Hygiene Washer
  - Auto Tensile Strength Test Machine
- Medical Device Automated Assembly Solutions

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Source: Company | ALPHA Research @ Spiral Thinker Group

![Image of various automation solutions and company logo](Image)
Revolutionary Breakthrough Full Range Technologies for IGBT/Power Module Solutions

Assembly | Test | Final AOI | Packaging

- Laser Marking
- DBC Segregation
- Pin Insertion
- Epoxy Dispense & Housing Attach
- Module Test
- Final AOI+Packaging

Source: Company | ALPHA Research © Spiral Thinker Group
SENSING & IMAGING IN FUTURE AUTOMOTIVE

VSCEL Technology is the Key Building Block for 3D Sensing

Source: carmagazine.co.uk | blogs.intel.com | gorgia.no-ip.com | smallworldsocial.com | fierceelectronics.com
Strategic position to benefit from growth trends

Key technology trends driving the sensing market

- **Next generation displays**
  - μLED displays with full sensor-display integration
  - Smart watches, mobile devices, smart home and building, in-car displays and HABA/Industrial

- **Autonomous driving**
  - LIDAR solutions with VCSEL- and EEL-based offering
  - Leveraging front and rear lighting systems as LIDAR/sensor hubs

- **Digital automotive lighting**
  - Miniaturized light projectors for exterior and interior lighting solutions

- **Next generation imaging**
  - Ultra small wafer-level cameras for AR/VR glasses
  - Heads-up displays in Automotive

- **Bio-sensing**
  - Bio-sensing using mid-IR tunable laser and detector
  - Optical read-out for Lateral Flow Test (LFT)
  - Take on the challenge of non-invasive glucose monitoring

- **Industrial IoT**
  - Presence detection and personalization
  - Position detection
  - Smart functions

- **In-cabin sensing (ICS) / HMI**
  - Driver monitoring including attention and health + comfort settings
  - Gesture detection and authentication

Source: Company | ams.com
KLSE : PENTAMASTER CORP. BERHAD

Key Financial Figures

- MARKET CAP. : RM3,554m
- PRICE : RM5.00
- PE RATIO : 42.8x
- DY : 0.2%
- OaCY : 3.9%
- Cash Position : Net Cash
- Profit Margin : >24%
- 3Y REV CAGR : +20.0% p.a.
- 3Y NP CAGR : +28.5% p.a.
- 3Y OCF CAGR : +59.6% p.a.
- 3Y PE RANGE : [15x, 26x]
Management Guided Prospects from 3QFY20 QR

Prospect

With the on-going threat of Covid-19 impacting world economies and the continuous infection wave crippling the socio-economic aspect, year 2020 has been highly disruptive as the Group enters into the remaining months of 2020. Towards this end, the Group has been tirelessly stepping up its effort in managing its project delivery and installation timeline taking into consideration the tedious application process for cross border travelling imposed by the Malaysian government. In parallel, the Group is actively evaluating its strategic expansion opportunities outside of Malaysia to broaden its footprint regionally, whilst acknowledging the fact that pandemic risk remains real and the Group needs to anchor a diversified environment for its long term growth plan.

During the period, with the exception of the Group’s electro-optical division (previously known as telecommunications division), the Group continues to witness positive business growth momentum from the rest of the Group’s division in the ATE and FAS business segments. The Company’s recent incorporation of Pentamaster MediQ Sdn. Bhd. (“PDSB”) and its allocation of capital expenditure for PDSB shows the Group’s proactive approach in broadening its business exposure, especially towards the ever growing medical device segment. Currently, the Group has continued to expand its strength, technology capabilities as well as its product portfolio in the electro-optical capabilities, while capitalising the market potential on silicon carbide (SiC) and gallium nitride (GaN) – based compound power semiconductors and power modules. The i-ARMS solution of the Group has also been bearing fruits with the wider adoption of robotics and automation.

Source: Company 3QFY2020 QR
3 KEY GROWTH AUTOMOTIVE SEGMENTS

Automotive Lighting & Infotainment Systems

2018-2024 Automotive lighting market forecast

(Source: Automotive Advanced Front-Lighting Systems 2019 report, Yole Développement, 2019)

Source: yole.fr
3 KEY GROWTH AUTOMOTIVE SEGMENTS

Lighting & Infotainment Systems Driving LED and Sensors Content

Source: grandviewresearch.com | businessinsider.com
KLSE : D&O GREEN TECHNOLOGIES BHD

Automotive Interior & Exterior LED Supplier

SMART RGB

EXTERIOR ILLUMINATION

DOMINANT Opto Technologies
Innovating Illumination

FY2019 REVENUE CONTRIBUTION

97% AUTOMOTIVE

Source : Company

Source : Public Investment Bank
KLSE: JHM CONSOLIDATION BHD

Transition of Xenon, Halogen light to LED to Boost to JHM Outlook

SAFER FOR YOUR DRIVING!!
Adapt for all harsh weather conditions. Brightness increase of 3 times, width increase of 2 times, range increase 3 times

Clientele:

MLS AUTOMOTIVE
OSRAM Opto Semiconductors
LUMILEDS

FY2019 REVENUE CONTRIBUTION

66% AUTOMOTIVE
33% INDUSTRIAL
1% AEROSPACE
WHAT IS AN MCU?

An MCU is an intelligent IC that consists of a processor unit, memory modules, communication interfaces and peripherals. The MCU is used across a broad range of applications, including washing machines, robots, drones, radio and game controllers.

Technically, an MCU functions by executing the program instructions stored in its non-volatile memory module. MCUs used to be ROM-based, so erasing the program data used to be difficult, if not impossible.

Most modern MCUs use the RISC (Reduced Instruction Set Computer) instruction architecture for its fundamental instruction processing. The RISC offers a shorter instruction execution cycle compared to its predecessor, CISC.
KESM (SUNRIGHT) Positioned to Benefit from Higher Content

**Vehicle Production**

**Drivers For Semiconductor Content In Cars**

- ADAS
- Safety
- Infotainment

### WW Production

- Assisted Driving
- Semi-Autonomous
- Fully Autonomous
- Driven By Regulations
- Industry Driven To Achieve “Zero Accident”
- Connectivity
- Trickling Down to Mid-Range Cars

Source: MIS Feb 2019
## Automotive Semiconductors: Most Stringent Burn In Testing Requirements

**Figure 10: Challenges for semi producers and OEMs**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Consumer</th>
<th>Industrial</th>
<th>Automotive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>0 – 40°C</td>
<td>-10 – 70°C</td>
<td>-40 – 160°C</td>
</tr>
<tr>
<td>Operation Time</td>
<td>2 – 5 years</td>
<td>5 – 10 years</td>
<td>Up to 15 years</td>
</tr>
<tr>
<td>Humidity</td>
<td>Low</td>
<td>Environment</td>
<td>0% – 100%</td>
</tr>
<tr>
<td>Tolerated Field Failure Rate</td>
<td>&lt;10%</td>
<td>&lt;&lt;1%</td>
<td>Target: 0 failure</td>
</tr>
<tr>
<td>Documentation</td>
<td>Minimal</td>
<td>Conditional</td>
<td>Required</td>
</tr>
<tr>
<td>Supply</td>
<td>Average 1 year</td>
<td>~ 2 – 5 years</td>
<td>Up to 30 years</td>
</tr>
</tbody>
</table>

Source: PwC analysis
Key Financial Figures

- MARKET CAP.: RM452.2m
- PRICE: RM10.52
- PE RATIO: n/m
- DY: 0.7%
- OaCY: 18.9%
- Cash Position: Net Cash
- Profit Margin: < 3%
- OCF Margin: > 30%
- 3Y REV CAGR: (11.7%) p.a.
- 3Y NP CAGR: (86.5%) p.a.
- 3Y OCF CAGR: +3.5% p.a.
CONCLUSION

Global Automotive Sales Back into Growth Trajectory

IS A REBOUND ON THE HORIZON?

Light vehicle production (year-over-year growth)

North America (16.3m units in 2019)

-3.8% -20.9% 17.6% 1.8% p.a.
2019 2020 2021 2021-2025

Europe (21.1m units in 2019)

-3.8% -24.1% 16.7% 2.5% p.a.
2019 2020 2021 2021-2025

Greater China (24.7m units in 2019)

-8.1% -9.1% 6.3% 4.7% p.a.
2019 2020 2021 2021-2025

Japan / Korea (13.1m units in 2019)

-0.7% -17.1% 7.2% 1.5% p.a.
2019 2020 2021 2021-2025

RoW (13.7m units in 2019)

-9.6% -31.2% 24.5% 8.1% p.a.
2019 2020 2021 2021-2025

World (88.9m units in 2019)

-5.6% -19.4% 13.2% 3.8% p.a.
2019 2020 2021 2021-2025

Source: Based on or includes content supplied by IHS Markit, Automotive Group: Light Vehicle Production Forecast. September 2020.
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