Miniaturised Medical Devices

IME's Miniaturised Medical Devices (MMD) programme collaborates closely with clinicians, cross-disciplinary research institutes and medical industry partners to address and develop technical solutions for unmet clinical needs.

The programme designs, fabricates, characterises and provides bio-packaging solutions for highly sensitive micro-electro-mechanical system (MEMS) sensors that can measure various physiological parameters in the human body. Such sensors are combined with application-specific integrated circuits (ASIC) and wireless interface to enable highly integrated devices for the medical / healthcare industries.

Capabilities

**Biomedical ASIC Platform**
- MEMS sensor interface ASIC
  - For versatile biomedical healthcare applications (EEG, ECoG, ECG, intracranial pressure / oxygen / temperature sensor, blood flow sensor, force sensor with guidewire)
- Power electronics
  - High efficiency DC / DC conversion
- Signal conditioning circuit module
  - Minimisation of the implant leads number via I²C (Inter-integrated circuit) interface
  - Enhancement of signal-to-noise ratio
- Low-power consumption biomedical ASIC
  - 1.16mW for implantable 100 channels probe array neuromonitoring applications
  - 630μW for implantable prosthetic graft blood flow monitoring

**Medical Device Platform (Sensors / Transducers)**
- High density 3D neural probe array monitoring microsystem
  - For deep brain neural recording / stimulation application
  - Probe electrode impedance <500kΩ @ 1kHz
- Wireless intracranial pressure (ICP) microsystem
  - For multimodality (temperature, oxygen and pressure) neuromonitoring of severe head injury patients
  - Pressure, oxygen and temperature sensors sensitivities are 18.6aF/mmHg, 194pA/mmHg and 2mV/C, respectively

- Wireless data / power transmission ASIC
  - Wireless & connectivity technologies (wireless body area network, WiFi, BT, Zigbee and RFID)
Wireless implantable blood flow monitoring microsystem
- For early prosthetic graft failure detection
- Powered by 630μW transmission power; wireless pressure sensing resolution of <0.2psi

Sensorized guidewire integrated with ASIC
- To aid surgeons in endovascular procedures of peripheral artery disease
- Tactile sensor with force range of 0–160mN, detection sensitivity of 1.5mV/mN, compatible with 360μm diameter guidewires

Renal denervation guidewire
- To address resistant hypertension and other abnormally highly activated sympathetic disease
- Monolithically integrated sensors (tactile, temperature and heater) with one piece roll-up structure

Wearable sensor patch
- For early extravasation detection to prevent intravenous complications
- High sensitivity (45% ΔR/ml) of sensor patch and can detect less than 2ml infusion volume

Design / Simulation / Fabrication

Biomedical Device Biopackaging Platform
- Ex-vivo test and in-vivo trial (IACUC approval)
  - Approved by Institutional Animal Care and Use Committee (IACUC)
- Clinical trial (CIRB approval)
  - Approved by Centralised Institutional Review Board (CIRB)

System-level Integration & Validation

In-vitro Cytotoxicity Validation  In-vivo Animal Trial  Human Trial

Biomedical Device Validation Platform
- Bench top test
  - Evaluation of medical device's performance via bench top test
- In-vitro cytotoxicity test (ISO 10993-5 biocompatibility standards)
  - Evaluation of biocompatibility of device via in vitro cytotoxicity test subjected to ISO 10993-5 standards
- Die attach
  - Manual and automated dispensing
  - Conductive and nonconductive epoxy (organic) die attach materials
  - Low-temperature curing silver adhesive dispensing
- Wire bonding
  - Manual and automated wire bonding
  - Wedge and ball bonding using gold wire, aluminium wire, and X-wire™ (insulated) wire
  - High wire count for ASIC
  - Wire bonding to organic flexible printed circuit board (FPCB) and metal packages
- Flip chip assembly
  - Eutectic (Gold-Tin) solders
  - Gold stud bumping (wafer or die)
  - Plastic (polyimide) substrates
- Laser solder ball jetting and laser cutting
  - Gold-Tin (80 - 20 weight %), SAC305 solder ball material
  - 40μm, 60μm, 120μm and 250μm in versatile diameters
  - Laser solder ball jetting speed of 6 balls per second
  - Laser cutting width of 25μm (FPCB)
- Biocompatible encapsulation and coating
  - Parylene-C conformal coating
  - Naflion medical gel coating (oxygen sensors)
  - Polydimethylsiloxane (PDMS) encapsulation and coating
  - Polyimide-2611
- Packaging and assembly design / development
  - Package design and characterisation
  - Materials selection and evaluation
  - Packaging and assembly process development
  - Full custom microsystem integration
  - ISO 9001 registered high-reliability ASIC packaging
  - MEMS packaging and flexible / surface mount assembly
  - Ultra-miniaturisation (3D packaging and integration)

**Applications**

- Wearable dry active electroencephalography (EEG) cap
- Wearable extravasation sensor patch
- Prosthetic graft with MEMS-based flow sensor
- Sensorised vascular guidewire
- Renal denervation guidewire
- High density 3D neural probe array
- Wireless intracranial pressure monitoring microsystem

IME’s device platforms for neurology, diagnostics and cardiology applications
• **Chronic Implantable Medical Devices**  
  (Cardiology)  
  - Vascular graft sensor extends graft life and reduces the number of routine graft scans  
  (Neurology)  
  - Wireless implantable neurodevice microsystem allows patients to regain independent mobility  
  - Intracranial pressure microsystem minimises the risks and results in a safer and more accurate traumatic brain injury monitoring approach

• **Minimally Invasive Surgeries**  
  (Cardiology)  
  - Intelligent endovascular guidewire increases success and safety of vascular surgeries  
  - Renal denervation guidewire with tactile sensing abilities enhances the effectiveness of renervation procedure  
  (Neurology)  
  - Ultrasound brain catheter aims to provide effective, safe and low cost hemorrhagic stroke treatment

• **Wearable Monitoring Devices**  
  (Diagnostics)  
  - Extravasation sensor patch improves patient care and reduces hospital stay  
  - Cricoid force sensor provides a quantifiable and consistent applied force for intubation procedures  
  (Neurology)  
  - Gel-free dry EEG electrode improves patient experience and long term EEG recording efficiency

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**COLLABORATE WITH IME**

**One-To-One Collaboration:**  
Access to advanced multi-platform technologies including nano-photonics, nano-electronics, bioelectronics devices, micro-electro-mechanical systems (MEMS) and advanced packaging.

Interactive collaboration framework with a suite of guidelines on design technology and integration system.

**Services:**  
- Multiple-Projects-Wafer Prototyping  
  - Silicon Photonics  
  - 2.5D Through-Silicon Interposer (TSI)  
  - Micro-Electro-Mechanical Systems (MEMS)

**R&D Foundry**  
- Fully integrated line of 200mm and 300mm state-of-the-art manufacturing systems

**Consortia:**  
IME-led public-private platform for multiple companies to develop leading edge relevant R&D to sustain growth and competitiveness.

**Technology Licensing:**  
IME licenses its technology or Intellectual Property (IP) to industry collaborators through Exploit Technologies (ETPL), the commercialisation arm of A*STAR.

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**An ISO 9001 and ISO 13485 Certified Organisation**

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