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COLLABORATIVE RESEARCH IN ENGINEERING, SCIENCE & TECHNOLOGY

CREST Cluster Focus & Projects

23rd February 2015

Key Programmes 2015-2017

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Clusters focus	1. Opto-electronics/LED and Solid State Lighting	2. Embedded System & Internet of Things	3. IC Design, Test & Validation	4. Advance Materials & Packaging	5. World-Class Electronics Manufacturing	6. Drones, Driverless vehicle, Autonomous Vehicle Tech.
Domain Areas	Compound semiconductor engineering (III-V)	Data Analytics, Big Data Science	Advanced testing (IC/Board/SW) - Probe cards, JTAG	Semiconductor device packaging - Multi-chip packaging (TUV, TSV)	Industrial Automation & Robotic	Autonomous aerial vehicle technology
	Thermal materials	Advanced wireless communication	IC Design automation	Cheaper Epoxy/Materials for Mass-Market Optoelectronics	Low Volume, High Mix (adaptable mfg)	Gyroscopic stabilisation system
	Advanced Polymers	Sensors & Sensing	Advanced Logic Emulation	Compound semiconductor engineering (III-V)	Smart factory, IoT in manufacturing	Closed-loop digital control system
	High Power Electronics Interconnect	Energy systems - harvesting, storage, management	UI/UX-specific SoC/IC/FPGA design	Nano-materials and structures for interconnects, circui try, thermal management	Additive Manufacturing & 3D Printing Technology	GPS and geo-fencing technology
	Optical Inspection of Emi-translucentt surface	Organic, Printable electronic		Materials for 3D printing, inkjet printing	Integrated Design to Manufacturing, Supplier in Design	Navigation and guidance
	Smart / Autonomous Lighting System	Wearables			Connected Supply Chain	Lightweight materials
		Markets - healthcare, transportation, manufacturing, retail, smart city, agriculture			Computer Integrated Mfg; Efficient Mfg Scheduling System	Energy efficient drives

Cluster: Opto-electronics/LED and Solid State Lighting

1. Opto-electronics/LED and Solid State Lighting

Solid-state lighting (SSL)

Solid-state lighting (SSL) is the most promising energy saving solution for future lighting applications. Because the light from SSL is narrowband, and can be concentrated in the visible portion of the spectrum, it has, like fluorescence, much higher light-emission efficiency than incandescence. Unlike in fluorescence technology, the wavelength of the narrowband emission can be tailored relatively easily. Hence, this technology is even more efficient than fluorescence. Lighting is going through a radical transformation, driven by various societal, economical, and environmental needs and rapid progress of SSL and system-related technologies. In 2005, lighting sources is attributed to 19% of global energy consumption. Migration towards highly efficient LEDs could potentially safe 500 coal power plants (500MW) based on those figures.

Research interests in this area includes deposition methods for epitaxial layer technologies, thermal interface material and thermal management, various polymers for LEDs and smart and autonomous lighting systems.

Cluster: Opto-electronics/LED and Solid State Lighting

1. Opto-electronics/LED and Solid State Lighting

Thermal Materials

An important aspect towards more sophisticated electronics and higher brightness LEDs relates to its thermal management capabilities. With better thermal management capabilities, power electronics could run at higher power rating, logic devices could operate at higher operating conditions, and LEDs could operate ah higher brightness levels; thus reducing LED chips required for a package/system.

As such, materials with superior thermal management properties will have a profound impact on the LED industry; but would potentially impact other sub-sectors within the electronics industry.

Research domain includes thermal interface materials, thermal modelling and coatings.

Cluster: Opto-electronics/LED and Solid State Lighting

1. Opto-electronics/LED and Solid State Lighting

Advanced Polymers

The rapid growth of the LED industry has fuelled the needs for polymers with superior properties such as high refractive index, UV resistant, and thermal resistant.

These properties reflect technological developments at the LED front, looking into high brightness devices, laser lighting, and overall revamp of how light sources are designed.

Interestingly, the availability of novel polymers will create opportunities for new designs especially in package component and system level development.

Cluster: Opto-electronics/LED and Solid State Lighting

1. Opto-electronics/LED and Solid State Lighting

Smart Lighting

Smart lighting is the domain where LED converges with IoT. There are many ways smart lighting can impact human lives. Below are some examples (non-exhaustive) of potential applications:

- Impact on human mood
- Perceived lighting
- Energy conservation via human presence detection
- Means of data communication
- Leveraging on big data

Big Data, Data Analytics

As the amount of data generated by and shared through the Internet soars to 44ZB by 2020, a new field of data science and data analytics is emerging as a promising new research area with the prospects of huge value creation.

Massive amounts of data are being generated by an estimated 50B sensors, and that data must be transported and federated to large server installations through common data frameworks for interoperability and security protocols to ensure data integrity. The data must then be analyzed using various analytics techniques on large scale computing installations, recognizing patterns through creation of novel analysis algorithms and then creating insights and drawing conclusions. Example applications of an interconnected system such as this include city-wide energy management or traffic management, surveillance and security systems, industrial factory automation, retail and commercial building management, or advanced vehicle or fleet logistics.

Research interests in this area would include data structures for efficient collection, communication, and analysis of data; communications and security protocols; data algorithm creation and optimization; data security; distributed computing; distributed system synchronization; system performance and performance optimization; and system autonomy.

Advanced Wireless Communications

Our world is increasingly connected by a myriad of wireless communication protocols. Smartphones, GPS signals, low-energy Bluetooth, and industrial communications standards offer a standard, high-speed mechanism for large transfers of data. The Internet will approach 44ZB of data by 2020, with all of the data needed to be fully interconnected and interoperable. New devices will require new communications protocols to optimize their power consumption and performance needs. And in the background, our wireless spectrum is increasingly crowded and innovative techniques must be created to improve the data delivery efficiency using the spectrum available.

Research interests in this area would include novel techniques for data transmission; usage of communications spectrum; low power communications; research into usage of new spectra for communications such as visible or UV light; device-side receiver and transmitter optimizations; data transmission security.

Sensors and Sensing

The development and application of sensor technologies in devices and systems will improve user interaction (UI) and user experience (UX) simply by representing and enhancing the senses of human. Sensors technologies can provide well conditioned signal to be used in statistical analysis based on specific criteria to allow a robust, consistent and efficient decision making to take place. The adoption of sensors in smart electronic gadgets can be seen throughout the consumer market place however the maturity of the technology from application and desirability perspective are still in its development stage. Therefore the ability to unleash the full potential of sensors is encouraged.

One important area to support the development of sensors is the ability to accurately emulate the various types of activities; be it from human or machines; that sensors take as inputs. This is seen as the first crucial step towards the development of sensor technologies to enable the end goal of providing a complete solution to mankind. Once the well represented activity is obtained, the next step will be to provide the proper analytical computation based on desired criteria for the execution of a particular decision. The later requires in-depth understanding and quantification of user's behavior and situational awareness. The final step will be the development of new age sensors to tap into inputs without the need of physical interaction and one good example is the electroencephalogram (EEG). The EEG will further push the boundary of UI and UX towards a mind controlled future.

Continue to next page….

Sensors and Sensing

The advent of internet of things (IoTs) will escalate the need for smart devices to sense and interact with its surrounding environment. Sensors are the primary building block for any IoT application to sense and collect data for analytics purpose. Silicon based accelerometer used to find its application in automotive industry to measure the vehicle movement (yaw, lateral movement) for their active suspension systems and vehicle stability assist system. Today, a typical smartphone not only is equipped with such accelerometer, it also has gyro, light, proximity, temperature, sound sensors etc. to make them “smart”. Accelerometer is now commonly used to detect the fall of the smartphone/walkie-talkie user (or detect the phone screen orientation). As new application demand becomes more intense, newer sensors may need to be developed. An area that’s of high growth is the biomedical sensors. These biomedical sensors to detect glucose level, oxygen level, or osmolality may be slow, but they are needed to interact with human tissue, hormones, neurotransmitters, cytokines etc. Hence, an opportunity arises.

Electrical Grid Energy System Management

Reliable, clean, affordable energy is fundamental to every sector of the economy. The Malaysian National Energy Policy of 1979 identified three principal energy objectives: 1) supply (adequate, secure and cost effective), 2) utilization (efficient usage), 3) environmental (minimize negative impacts). To achieve these objectives, continued research is needed in the areas of:

- Electricity supply and demand management
- Phasor Measurement Units (PMU) utilization to stabilize the grid
- Energy efficiency
- Storage, both grid-tied and isolated
- Demand response protocols
- Microgrid deployment and IT security
- Low energy harvesting

All of these research areas have the potential to increase energy reliability, reduce costs, and decrease emissions from fossil fuel consumption.

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Electrical Grid Energy System Management

Battery Technologies

With the increasing use of battery-operated devices such as mobile phones, laptop computers, tablets and power tools, there is a greater need for batteries that have higher energy densities to power such devices. Not only are batteries needed with higher capacities but also lighter and smaller as well as the ability to be recharged faster and to have more charge cycles. The impact gets worse as wearable computing devices, electric vehicles and the Internet of Things take hold. Whilst there are incremental changes and improvements to battery technology, we are still very much tied to the Lithium Ion Battery technology that was first commercialized in the early 1990s. There is significant research around the world to develop other forms of batteries (eg fuel-cells, super-capacitors) as well as improving the materials used in the typical Li-Ion battery designs such as using different materials for the cathode and anode of the battery as well as different electrolyte material. These may include nanobatteries, or the use of titanium dioxide anodes, or silicon anodes or lithium-iron phosphate cathodes to many other differing materials and structures. The challenge then is find the materials or solutions that can be commercially viable that meets the demands of the ever-increasing need of higher energy densities along with the other requirements of fast charging, lighter, smaller and at the same time safe and reliable.

Printed Electronics

Whilst traditional silicon electronics continues on it's relentless miniaturisation path, there is an emerging opportunity for Large Area and Low Cost/Disposable active devices which exploit technologies of printing and coating onto substrates such as plastic and paper.

The vision here is to make products such as solar cells, Displays, RFID tags, Wearable sensors/detectors where large size is a requirement or a benefit and where traditional inorganic/silicon manufacturing techniques are too expensive. The technologies of printing, such as ink-jet, offset-litho, screen etc need to be combined with novel materials such as conductive inks, transparent conductors, organic semiconductors, functional polymers etc *and* low-cost substrates such as paper, plastic or metal films to create thin, flexible, environmentally-friendly, disposable, degradable devices in applications such as sensing, energy capture/storage, data transmission, illumination etc. This involves new manufacturing technology development, new material technology development plus the smart combination of traditional silicon/inorganic tech to make novel devices

Wearable Technology

The miniaturization of the integrated circuit and of communications technologies, along with advances in wireless communications, have made possible the creation of personal devices that can now be worn on a person's body as sort of companion. There are many applications for such devices in the fields of health monitoring, wellness, activity monitoring and fitness tracking, personal communications, enhanced human vision, virtual reality, bionics, and cosmetics.

Wearable technology is an exciting and developing field in its infancy, and there are advances in many fields needed to make wearable technology a ubiquitous. Research interests in the areas include advanced materials research for flexible or organic materials; low power integrated circuits; advanced battery and power delivery technologies; energy harvesting systems through kinetics or bio sensing; bio sensor research; skin-to-machine interface technology; wearable data input innovations; voice recognition and data translation; advanced visualization technologies; miniaturization for packaging and system integration.

Cluster: IC Design

3. IC Design, Test & Validation

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Advanced Circuit Emulation

As the Integrated Circuit becomes more ubiquitous in our daily lives, reaching $300B in worldwide sales and one trillion units in 2015, the needs to create more devices and shorten the development time to market continue to increase. Traditional IC design techniques used are to simulate using software some elements of chip design prior to manufacturing, then use hardware debug techniques to verify operation. Increasingly with complex circuits, this approach is inadequate to verify correctness of the circuit prior to manufacturing, and costs of generating a die for testing are increasing as process technologies get more complex, reaching into the millions of US Dollars per component. An alternative technique is to emulate advanced logic and analog circuits using Field Programmable Gate Arrays or similar programmable logic ahead of manufacture, thus saving effort in debug.

Research interests in this area include FPGA and board modeling accuracy of IC circuits; board design technologies for rapid prototyping; building validation stimulus patterns to test circuits; correlation of emulation results to real device behavior; correlation of emulation data to simulation and debug validation data; new software algorithms to reduce post silicon debug test requirements based on emulation results.

IC Design Automation

The Integrated Circuit has become a ubiquitous technology that impacts our daily lives in countless ways, from computers to transportation systems, building automation to smartphones, home appliances to entertainment. The worldwide semiconductor industry is expected to top $300B in 2015 with more growth to come, and the number of devices is expected to exceed one trillion. With more and more chips being designed every year, the need for design tools and automation to aid in reducing the development cost and time to market of devices is ever present in the industry. The design complexity of these devices is increasing, as Moore's Law continues to deliver advances in manufacturing scale – and the tools used for design must keep pace. Research interests in this area include advanced digital and analog modeling; design for test and design for manufacturing circuit automation; automatic place and route; optimization of existing systems for performance and cost; automatic insertion of test and design rules; automation for new process technologies; creation of layout and on-die standard protocols for speedy integration; automated pre-silicon validation.

Cluster: IC Design

3. IC Design, Test & Validation

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Advanced Testing

Development and innovation of new test methodology and solution for enabling the exploration of new technologies in electronics, telecommunication, wearable and renewable energy.

Key areas of research and development include:

- high-speed (>10Gbps) and ultra high capacity networks (5G, 802.11ad and beyond) next generation wireless standards
- high-speed digital interfaces and signal/power integrity analysis (eg. PCIe Gen4, Multi-gigabit Transceiver, Thunderbolt, HDMI and beyond)
- wireless charging and low power new field communication (eg. A4WP, Smart NFC, ZigBee/6LoWPAN)
- RF/Microwave signal generation and analysis, high dynamic range and very low-level (<-50dBm) power measurement, mmWave (>50GHz) signal switching/splitting/transmission
- data acquisition and measurement technologies
- Low power high-speed data conversion (analog to digital, digital to analog), low noise analog signal conditioning/amplification/filtering, digital signal processing algorithm and hardware

Cluster: Advance Materials & Packaging

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4. Advance Materials & Packaging

Semiconductor Device Packaging

As semiconductor technologies continue to permeate everything in our daily lives, and become more personal, the devices we use are becoming smaller and more powerful every day. The semiconductor industry has successfully scaled performance and cost through Moore's Law, but the packaging of semiconductors has not yet approached the same sort of complementary scale due to cost or technology constraints. Increasingly, multiple semiconductor devices must be grouped together to create a single, miniature component module, and semiconductor devices are being stacked to form 3D blocks of circuits. As we move to the era of wearable, printable, and consumable components, packaging must change to be more flexible, organic, digestible, renewable, dissolvable and follow the same integration cost and size advantages as Moore's Law provides for semiconductor devices.

Research in this area would include advanced materials science research; new materials for flexible or consumable electronics; stacked circuit techniques for advanced integration; packaging substrate manufacturing technology; advanced test techniques for miniature packaging; nano-scale packaging; sustainability or recyclability of packaging materials and manufacturing techniques.

Compound Semiconductor Materials

Compond Semiconductors offer properties & capabilities exceeding those of normal silicon-based devices, enabling improved efficiencies, higher speeds and greater powers in a variety of applications. Arguably the worlds first commercial nanotechnology, LEDs based on III-V systems are in a phase of rapid development where there are great industrial needs for lower costs & higher efficiencies. Compound Semiconductors have been used to produce the highest efficiency Solar Cells ever reported and can enable improved RF circuits and more efficient power supplies.

There are opportunities for research in all these areas, and great opportunities to exploit basic III-V epitaxy to customise solutions for these emerging applications. Solid State Lasers and customised light sources for sensors in medical/health/wearable markets is a further area where basic compound semiconductor technology can be exploited.

Cluster: Advance Materials & Packaging

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4. Advance Materials & Packaging

Cheaper Epoxy/Materials for Mass-Market Optoelectronics (MMMO)

Optoelectronic components are appearing in virtually all consumer electronics and many industrial and automotive products, in the near future Opto devices will be the sensors & detectors in wearable devices & autonomous vehicles . The extent of penetration of opto devices is ultimately limited by factors of size & cost.

There are opportunities to research new classes of polymers and develop novel encapsulants, housings & lenses which offer lower costs, greater stabilities, smaller form-factors, recyclability etc. In addition there are large industrial demands for low-cost epoxy and silicone systems to meet the needs of consumer electronics - for these 'mature' technologies much base IP has expired, creating new opportunities for SME & Start-ups to duplicate & improve materials which are already in high-volume use.

Cluster: World Class Electronics Manufacturing

5. World-Class Electronics Manufacturing

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World Class Electronics Manufacturing (Automation/Robitics/Low vol-High Mix) (Smart Factory/Mfg)

In the pursuit of becoming a high income nation it is imperative for us to move away from labor intensive manufacturing. Electronic manufacturing may be divided into two parts, PCB assembly and model assembly. PCB assembly is standardized across the industry where standard components, with standard geometries used lead to many OEM (Original equipment manufacturers) developing solutions with similar performances. However, model or product assembly involves custom shaped mechanical parts which require dexterity (complex gripping/handling of component parts) and complex assembly motions instead of the simple pick and place of PCB assembly. This entails that there is no standard solution for model assembly, and therefore automation tends to be customized and expensive. There are many other factors that make model assembly automation expensive:

1) High mix environment (Flexibility) – how to deal with different shapes and sizes and materials
2) Demand Fluctuation - (Scalability) – How to ramp up and down manufacturing capacity
3) Safety - Up to 30% of the cost of automation is on ensuring that it is safe for operators
4) Space – The heavier the payload the bigger the motors, gantries, arms and base.
5) Cost of development - Engineering time and cost of prototypes

Continue to next page....

Cluster: World Class Electronics Manufacturing

5. World-Class Electronics Manufacturing

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World Class Electronics Manufacturing (Automation/Robitics/Low vol-High Mix) (Smart Factory/Mfg)

The rule of thumb is that a project should only be pursued if the ROI (return on investment) is 2 years. Since direct labor cost is approximately RM24K, automation project should not cost more than RM48K for each operator that it will replace.

Therefore research should focus on developing reliable (OEE effectiveness greater than 85%) low cost automation solutions. The areas of interest can include:

1) Developing automation methodology for converting manufacturing process specs into automation specifications. This can be use by local automation houses to assemble solutions by using off the shelf components
2) Advance Automation modeling and simulation to reduce cost of development
3) The output of focus area 1 can be used as the input to focus area 2 and vice versa.
4) Flexible and intelligent end effectors
5) How to incorporate, machine vision, latest sensors technology so that manufacturing processes can be integrated (e.g. inspection/test and assembly) and make the solution safer.
6) How to eliminate the need for enclosures.
7) Standard automation strategy – A well defined strategy with phases of automation.

Cluster: Drones, Driverless Vehicles / Autonomous Vehicle Tech.

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Drones

Personal pocket drones weighing just a few grams may soon become indispensable accessories, allowing people to take dronies instead of selfies and creating city-wide networks of sensors. At the RE.WORK Future Cities summit in London this week, researchers from the UK and the Netherlands have spoken about latest developments in the autonomous aerial vehicle technology, which is slowly penetrating various areas of human activities from package deliveries to land surveying, agriculture and medical care. Malaysian, Brahmal Vasudevan has invested a £1.25m Aerial Robotics Lab at Imperial College of London to develop and test autonomous flying robots.

Many potential applications and technology can be developed based on the drone's platform. This include, but not limited to gyroscopic stabilisation system, closed-loop digital control system, GPS and geo-fencing technology, navigation and guidance, lightweight materials, energy efficient drives and propulsions etc.

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