Nanyang-DSO Graduate Programme (NDGP) 2027/2028

By Temasek Laboratories @ NTU (TL@NTU) and DSO National Laboratories

Research Topics

The following are the research topics available for selection:

1. Design and Fabrication of III-Nitride high-electron-mobility transistors for 5G/6G Applications

Widebandgap semiconductor materials, such as Gallium Nitride (GaN), promise to revolutionise the world of microwave power amplifiers by providing high power density, linear operation and robustness up to mm-wave frequencies (30 to 300 GHz). New applications such as gigabit point-to-point 5G/6G wireless communications or automotive radar require mm-wave power amplifiers. Researchers have demonstrated improved power density using different III-Nitride alloys (e.g: ternary, quaternary based heterostructures) by shrinking the gate (e.g: 20 to 40 nm) fabrication processes. Despite the great potential of these new technologies, they still suffer from physical and fabrication issues which may prevent devices fabricated on GaN and other III-Nitride alloys from achieving the improved device linearity and reliability levels required.

To improve the transistor linearity, it is required to design novel device structure, device simulation, device fabrication processes and its characterization. The main objective of this research topic is to explore different approaches to realize mm-wave operating devices by the optimization of device architecture design (e.g. Fin-HEMTs), device simulation, device fabrication and its electrical (DC, Pulsed I-V and RF) characterization. The measured device data can also be correlated with the in-coming HEMT epi-characteristics as well as device processing parameters.

Supervisor: Prof Ng Geok Ing (EEE)
Co-Supervisor: Dr Subramaniam Arulkumaran (TL@NTU)

2. GaN based HEMTs for high-power RF applications

Widebandgap semiconductor materials, such as Gallium Nitride (GaN), promise to revolutionise the world of microwave power amplifiers by providing high power density, linear operation and robustness up to mm-wave frequencies (30 to 300 GHz). GaN-based high electron mobility transistors (HEMTs) have emerged as a promising technology for delivering high power at high frequency power amplifiers. This may lead to increase efficiency and reduce energy consumption. AlGaN/GaN-based HEMTs were studied extensively and demonstrated power densities up to 10 W/mm at 40 GHz. Beside their great promise, technological issues still impede the full exploitation of the potential foreseen for GaN-based devices. To push the power density, researchers have explored different approaches. For example, N-Polar GaN HEMTs, Multiple-Channel GaN HEMTs, AlN/GaN HEMTs, InAlGaN/GaN HEMTs, GaN-on-Diamond and etc…

The purpose of this work is to improve the present GaN-based HEMT technology, increasing device power density and its efficiency by the optimization of device architecture design (e.g. Multi-Channel GaN HEMT or GaN-on-Diamond), deep scaling to increase the operating frequency, device passivation to suppress the current dispersion, device fabrication and its electrical (IV, Pulsed I-V, CV and RF) characterization. The measured device data can also be correlated with the in-coming HEMT epi-characteristics as well as device processing parameters.

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3. Agentic Foundation Model for Multi-Domain RF Target Detection, Localisation, and Tracking

This project will develop a foundational model for wireless target detection, localisation, and tracking that can generate actionable inference from large-scale geo-location data. The research will fuse RF measurements from heterogeneous LEO and non-LEO sensors (space, airborne, maritime, and terrestrial) across communications and radar bands, including VHF and satellite signals, to estimate target position, motion, and confidence bounds in near real time.

Key challenges addressed include the investigation and development of an LLM-enabled agentic intent layer that translates analyst queries into mathematically rigorous processing workflows and returns interpretable natural-language findings with quantified uncertainty. Performance will be evaluated through simulation and validated, where possible, on real datasets, delivering a scalable and trustworthy inference engine for maritime, air, and satellite-domain situational awareness.

Supervisor: Prof Tay Wee Peng (EEE)
Co-Supervisor: Dr Sirajudeen Gulam Razul (TL@NTU)

4. Design and fabrication of colour centre qubits in isotopically purified diamond for quantum sensing

Colour centres in diamond (e.g. NV-centres) have been of interest for use as long-lived qubits for quantum sensing and compute. The optical excitation, manipulation and read-out techniques have been largely established in laboratory demonstrations, thus enabling the characterization of these colour centres, explicating their long coherence life-times up to ~ms even at room temperature. Such colour centres in diamond constitute a solid-state platform with the potential to scale in terms of qubit fabrication. However, the deterministic fabrication of such colour centres in terms of controlled clusters, and spatial segregation, degree of activation, and minimisation of background spin bath, remain key challenges, and constitutes a significant hindrance towards device reproducibility and the use of such NV-centres for reliable or mission critical applications. Materials engineering solutions that preserve the desirable quantum science in these colour centres are required to advance them for real world sensor applications.

This project will investigate the use of low ~keV ion-beam implantations to create deterministic colour centre clusters in diamond. The objective is to develop a fabrication technique to achieve controlled cluster implantation and activation of these colour centres, and compare their performance in natural and isotopically purified diamond. The work scope will involve materials characterisation, materials and defect-centre related simulations, and colour centre characterisation (e.g. by ODMR).

Supervisor: Prof Edwin Teo (EEE/MSE)
Co-Supervisor: Dr Johnson Goh (TL@NTU)

5. Development of high fidelity optical readout for defect centre qubits in diamond for quantum sensing

Colour centres in diamond (e.g. NV-centres) have been of interest for use as long-lived qubits for quantum sensing and compute. The optical excitation, manipulation and read-out techniques have been largely established in laboratory demonstrations, thus enabling the characterization of these colour centres, explicating their long coherence life-times up to ~ms even at room temperature. Such colour centres in diamond have been shown to be potential candidates for very low magnetic field and RF sensors advantageous for new applications in navigation and signal analysis. Optimising the read-out methodology for such low signal detection (<100 pT/√Hz) remains a challenging endeavour which needs to be overcome for impactful applications.

This project will investigate methods to enhance the read-out fidelity of such sensors such as correlated sensing, spin-charge conversion, Purcell enhancement, etc. with the objective to inform on a rational pathway toward miniaturisation of such colour-centre based sensing system. The work will involve optical instrumentation and close synergies with materials development researchers in the team.

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