Department of Biomedical Engineering
The Chinese University of Hong Kong

Graduate Seminar – PhD Oral Defence

Student	**:**	Mr. ALAM Md Masruck
Supervisor	**:**	Prof. GAO Zhaoli
Date	**:**	16 July 2026
Time	**:**	2:00 pm
Venue	**:**	Room 404, William M W Mong Engineering Building, CUHK

Title: High-performance Chemical Vapor Sensing with Functionalized CVD-grown SWCNT Field-effect Transistors

Real-time, non-invasive chemical vapor sensing is a critical requirement for rapid molecular diagnostics and environmental monitoring. However, the practical deployment of electronic nose systems fundamentally depends on sensing platforms that can simultaneously deliver high sensitivity, strong chemical selectivity, and long-term signal stability under realistic operating conditions. Carbon nanotube (CNT)-based field-effect transistors (FETs), particularly those based on single-walled carbon nanotubes (SWCNTs), represent a highly promising platform due to their exceptional electrical properties, large surface-to-volume ratio, and inherent compatibility with molecular adsorption processes. Despite these advantages, their performance in practical devices remains limited by substrate-induced charge disorder, insufficient chemical specificity at the sensing interface, and system-level signal drift during dynamic operation.

To address these challenges, this work presents a comprehensive CNT-based chemical vapor sensing framework that integrates substrate engineering, surface functionalization, and system-level control. At the materials level, CNT-FET performance is fundamentally constrained by charge inhomogeneity and electron-hole puddle formation in conventional SiO_2/Si substrates. To overcome this limitation, we develop a back-diffusion growth strategy to synthesize multilayer hexagonal boron nitride (hBN) on Ni-Cu gradient alloy substrates. This approach enables scalable fabrication of high-quality dielectric layers and establishes a uniform electrostatic environment for CNT/hBN heterostructure devices. At the interface level, chemical selectivity is enhanced through systematic molecular functionalization of CNT networks. Comparative studies of nucleobase-, DNA-, peptide-, and peptide nucleic acid (PNA)-based interfaces reveal structure-response relationships governing volatile organic compound (VOC) sensing behavior. Notably, PNA is introduced here as a highly stable molecular recognition layer, delivering a 5× enhancement in sensing response compared to DNA-based interfaces, with a detection limit down to 1 ppb and response times below 10 seconds. At the system level, hysteresis and baseline drift under continuous operation are mitigated using a digitally controlled readout architecture combined with a pulsed membrane-valve gas delivery system, reducing sensor drift from 40% to below 2%. In addition, frequency-dependent response analysis identifies 0.5 Hz as the optimal operating frequency, balancing signal amplitude with classification confidence.

***** ALL ARE WELCOME *****

For enquiries, please contact Ms. Joyce Chan, Department of Biomedical Engineering at 3943 8278