The Chinese University of Hong Kong
Department of Biomedical Engineering

Graduate Seminar – PhD Oral Defence

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Date	:	6 November 2024
Time	:	10:00 am
Venue	:	Room 713, William M W Mong Engineering Building, CUHK

Title: Scalable and Low-noise Micro Graphene Hall Sensors for Biomagnetic Sensing

The increasing demands for elevating human health and minimizing mortality pose significant challenges for the early diagnosis of disease. Due to the high sensitivity and CMOS compatibility, micro Hall sensor (μHS) is a promising miniaturized biosensor to answer this urgency. Graphene is a two-dimensional (2D) material owns ultrahigh carrier mobility and atomic thickness, which is particularly well suited to the application of high-performance μHSs. However, the inherent flicker noise (1/f noise) is non-negligible with the down scaling of micro graphene Hall sensors (μGHSs), which hinders further improvements of limit-of-detection (LOD). Moreover, flicker noise of μGHS arises from two key factors: current crowding effect (CCE) mediated contact noise at the graphene–metal interface, and fluctuations in carrier mobility within the graphene channels, further complicating the advancement of μGHSs.

To meet the requirements of biomagnetic sensing, we tackled both contact noise and dielectric-mediated noise of μGHSs. The contact noise of μGHSs was suppressed by applying persistent carbene treatment onto gold electrodes. The noise determined LOD of modified μGHSs was ~ 1440 $nT/Hz^{1/2}$ at 1 kHz, representing the lowest LOD for scalable μGHSs fabricated via photolithography. Meanwhile, we also developed a plasma enhanced chemical vapor deposition (PECVD) process to directly grow graphene/hBN heterostructures. The unique Moiré pattern with a wavelength of ~ 16.5 nm was observed by AFM, which confirmed the epitaxial growth of graphene on hBN. The reduced flicker noise level in heterostructure Hall sensor was attributed to the suppression of graphene carrier density inhomogeneity.

To realize the high-throughput detection of superparamagnetic objects, we integrated the microcoil and microfluidic system with the low-noise μGHSs. Moreover, we demonstrated the real-time detection of superparamagnetic nanoparticles (SNPs) and superparamagnetic microbeads (SMBs), validating the availability of μGHSs sensing platform for the early diagnosis of iron-related diseases and tumor metastasis.

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

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