Optical nanocavities for nascent extreme dimensional optoelectronics

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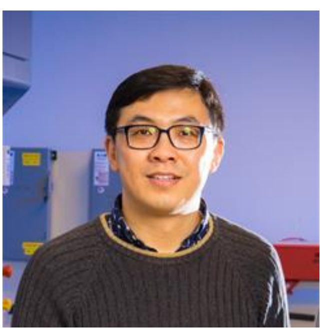
The past decade witnessed a rapid growth of ultra-thin and atomically-thin electronics and optoelectronics devices due to the advances in the development of new two-dimensional (2D) and ultra-thin nanomembrane materials. Although these new thin film materials opened opportunities for electronics and optoelectronics, their ultra-thin/atomically-thin film nature resulted in intrinsic limitations or challenges. For instance, in most thin-film energy harvesting/ conversion applications, there is a long-existing trade-off between optical absorption and thickness of semiconductor materials. When the absorptive materials are scaled down to ultra-thin (e.g. sub-50-nm) or atomically thin (e.g. sub-5-nm) dimensions, their light-matter interactions (e.g. optical absorption, energy conversion enfficiency, nonlinear optical response, etc.) are weak. To overcome this limitation, I will explain a planar nanocavity structure to enhance the light trapping within ultra-thin films and successfully demonstrated over 60% resonant absorption within a 1.5-nm-thick amorphous Ge film. Importantly, this planar nanocavity strategy can be extended to enhance light-matter interaction within monolayer of 2D materials. Therefore, this architecture will enhance the light-matter interaction of ultra-thin absorbing films and overcome the limitation between the optical absorption and film thickness of energy harvesting materials. More recently, my team successfully demonstrated nanomembrane Ge photodectors and 2D perovskite photodetectors boosted by this nanocavity strategy.



Short Bio:

Dr. Qiaoqiang Gan is a Professor in Physical Science and Engineering Division, KAUST. He received his Bachelor's degree from Fudan University in 2003, his Master's degree from

Chinese Academy of Sciences in 2006, and his PhD degree from Lehigh University in 2010. Before joining KAUST, he started his academic career at the Department of Electrical Engineering at the State University of New York at Buffalo (UB) in 2011, where he was promoted to Associate Professor in 2017 and Full Professor in 2020. At UB, he received 2019 SUNY Chancellor's Award for Excellence in Scholarship & Creative Activities. Dr. Gan is a Fellow of Optica (formerly Optical Society of America) and Fellow of SPIE. His research interests mainly include nanostructural construction and their applications in water sustainability, thermal management (passive cooling), biomedical sensing, and energy and environmental applications. In particular, his research activities aimed to bridge the gaps between fundamental investigation, application development and technology transfer (e.g. radiative cooling, solar-driven water purification and treatment technologies). He has published over 150 research articles in prestigious journals, including Nat. Sustain., Nat. Comm., Sci. Adv., PNAS, Adv. Mater. Phys. Rev. Lett. et al.. He is the Editor-in-Chief of IEEE J. Selected Topics of Quantum Electronics. He also served as General Chair and Program Chair for CLEO 2021-2023, and the Plenary session of Optics + Photonics meeting, SPIE, 2025.