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Programmable Nanoscale Building Blocks for Epitaxial Self-Assembly of Multifunctional Nanostructures

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Jin-Woo Kim, *Fellow, IEEE*

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Bio/Nano Technology Group, Institute for Nanoscience & Engineering, University of Arkansas, Fayetteville, AR, USA; Department of Biological & Agricultural Engineering, University of Arkansas, Fayetteville, AR, USA; Department of Biomedical Engineering, University of Arkansas, Fayetteville, AR, USA (*E-mail: jwkim@uark.edu)*

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Abstract

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Epitaxial assembly of multiple molecular/nanoscale particles into multifunctional structures with arbitrary sizes and shapes has the potential to transform many fields of research, ranging from optoelectronics and nanophotonics to nanomedicine. Self-assembly has emerged as a powerful and practical strategy for controlled synthesis of such multifunctional, hierarchical NP structures. Despite the promise and recent progress in NP self-assembly, the accurate, scalable, and high-rate epitaxial assembly of heterogeneous nanocomponents into multifunctional nanoarchitectures with specifically designed shapes and sizes remains a challenge in the field of nanotechnology. To meet the challenge, our group is in the process of developing nano-building block toolboxes (nanotoolboxes) for the programmable self-assembly of bio-hybrid multifunctional nanostructures with arbitrary shapes and arbitrary functions. This is accomplished with our novel technology that enables controls over the number, placement, and orientation of functional ligands, including DNA, RNA and peptides, on various NPs. This presentation will discuss the fundamental challenges to epitaxial self-organization of NP nanoarchitectures with specific shape and function, and present our strategies to realize the control and functionality necessary to overcome the challenges. Also, it will discuss the future directions for research in the field and their promise in applications through examples such as multifunctional and multimodal contrast nanoagents for medical theranostics.

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Jin-Woo Kim is a Director of Bio/Nano Technology Group and a Professor of Biological Engineering, Biomedical Engineering and Materials Science & Engineering at University of Arkansas and Adjunct Professor of Electrical Engineering at Pohang University of Science & Technology (POSTECH), and was Visiting Professor of School of Engineering & Applied Sciences at Harvard University and Center for Functional Nanomaterials at Brookhaven National Laboratory. His research focus is in the area of Bio/Nano Technology, i.e., biologically inspired nanotechnology, which spans interdisciplinary fields of biological/biomedical engineering, biology, chemistry, and nanotechnology. Learning from biological systems in nature, his research aims to develop more effective and efficient routes to “panoscale” (i.e., ‘any’ scale) system integration of multifunctional hierarchical structures for biomimetic advanced materials for biological and biomedical applications, including nanotheranostics, tissue engineering, and drug delivery. He has published over 150 articles, over 250 presentations with over 90 invited presentations and 5 patents granted/pending. He received several teaching and research awards, and is Fellows of IEEE (2022) and AIMBE (2017), and IEEE Nanotechnology Distinguished Lecturer (2017-2018). He is an Editor-in-Chief of IEEE Open Journal of Nanotechnology and has held leadership positions for international societies, President-Elect (2023) and Vice Presidents for Conferences (2021-2022) and for Publications (2017-2019) of IEEE Nanotechnology Council (NTC). He received his first B.S. in Chemical & Biological Engineering from Seoul National University, the second B.S. in Microbiology from University of Iowa, M.S. in Biology from University of Wisconsin, and Ph.D. in Biological Engineering from Texas A&M University.

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