PRESS RELEASE

GIST Researchers Showcase New Breakthroughs for Unlocking the Potential of Plasmonics

Scientists shed light on hybrid plasmonic nanomaterials with tunable properties, including clock-inspired designs featuring magnesium nano-rotamers

Plasmonics are unique light-matter interactions in the nanoscale regime. Now, a team of researchers from Gwangju Institute of Science and Technology, Korea has highlighted advances in shadow growth techniques for plasmonic materials, which have the potential to give rise to nanoparticles with diverse shapes and properties. They also introduce a method for large-scale production of nano-rotamers of magnesium with programmable polarization behavior, opening avenues for novel research applications.

Image title: Shadow growth techniques for plasmonic nanomaterials
Image caption: Researchers from the Gwangju Institute of Science and Technology, Korea present a comprehensive review of growth techniques for tailored plasmonic nanomaterials and reveal clock-inspired magnesium nano-rotamers.
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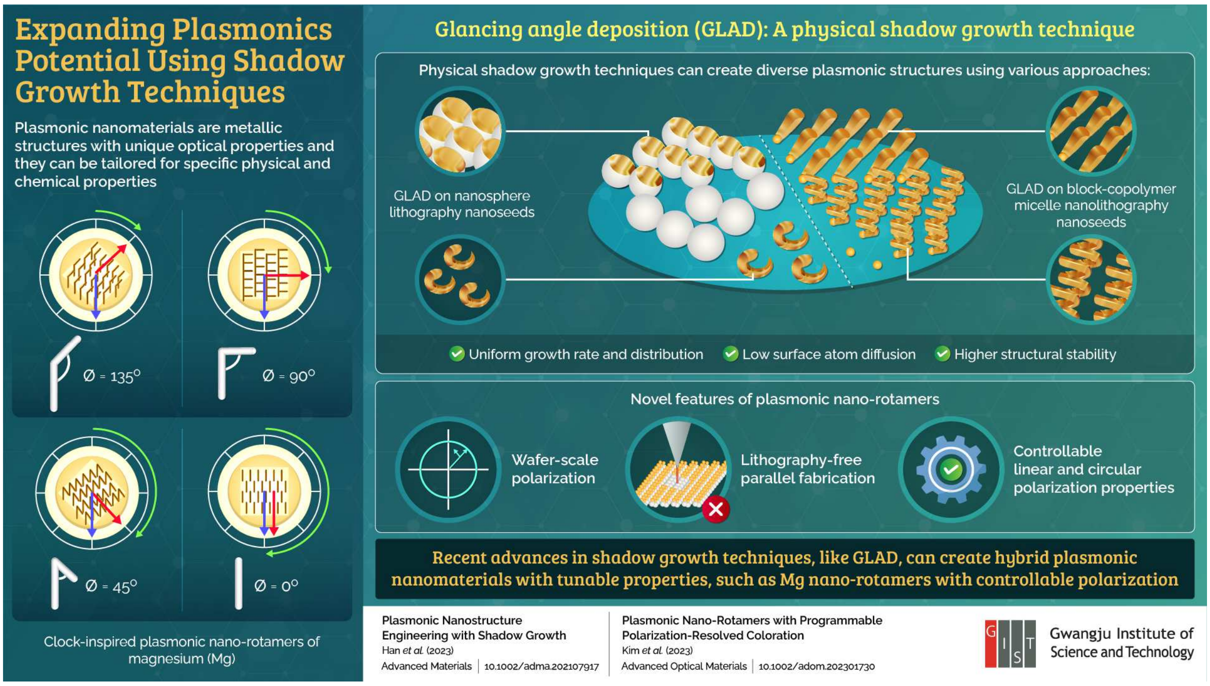

Plasmonics are special optical phenomena that are understood as interactions between light and matter and possess diverse shapes, material compositions, and symmetry-related behavior. The design of such plasmonic structures at the nanoscale level can pave the way for optical materials that respond to the orientation of light (polarization), which is not easily achievable in bulk size and existing materials. In this regard, "shadow growth" is a technique that utilizes vacuum deposition to produce nanoparticles from a wide range of 2D and 3D shapes in nanoscale. Recent research progress in controlling this shadow effect has broadened the possibilities for the creation of different nanostructures.

Now, in twin studies led by Assistant Professor Hyeon-Ho Jeong from the Gwangju Institute of Science and Technology (GIST), Republic of Korea, researchers have comprehensively shed light on the recent advances in shadow growth techniques for hybrid plasmonic nanomaterials, including clock-inspired designs containing magnesium (Mg). The studies were published in *Advanced Materials* on 25 March 2022 (with Jang-Hwan Han and Doeun Kim as co-first authors and Professor Peer Fischer and Dr. Jeong as co-corresponding authors) and *Advanced Optical Materials* on 20 November 2023 (with Juhwan Kim and Jang-Hwan Han as co-first authors and Dr. Jeong as the corresponding author), respectively.

The shadow effect here refers to the presence of "dark" areas on a surface that are concealed by "seed" molecules, and hence, inaccessible for the deposition of vaporized materials, much like shadow areas where light cannot reach. Elaborating on this further, Dr. Jeong says, "*Since these shadowed areas are the regions where the material cannot be deposited, an array of three-dimensional nanostructures can be formed. This formation depends on the size of the seed, spacing between the seeds, and the inclination of the substrate.*" Adding further, Doeun Kim, a Ph.D. student, says, *"Creation of unique nanostructures is influenced by the introduction of rotation during the process, based on rotation speed, time, and angle, ultimately forming three-dimensional nanostructures.*"

In the first study (featured as a cover-page article), the team showcased the production of various nanostructures using a specific shadow growth technique known as glancing angle deposition. These structures exhibit tunable optical properties achieved through suitable modifications to their material, shape, and surrounding environment. Their review also emphasizes a broad range of potential applications, including nano- and micro-robots for wound healing and drug delivery in the human body, photonic devices, and chiral spectroscopy, among others.

For the subsequent study, the team created 3D rotamers (molecules with specific rotational arrangements) capable of both linear and circular polarization, as well as of storing a significant amount of information. This clock-inspired design involves placing two nanorods made of Mg at a certain modifiable angle, resembling the hour and minute hands of a clock. These nanostructures also hold promise for various applications, such as the secure verification of items like banknotes, anti-counterfeiting devices, and displays capable of transitioning to desired optical states, as needed.

Talking about these developments and envisioning the future of plasmonics, Dr. Jeong says, *"These rotamers can have potential utilization in physically unclonable functions, an area currently under intensive research for ensuring robust security levels of hardware, such as PCs or servers."* Explaining further, Ph.D. student Juhwan Kim says, *"In particular, the ability to selectively filter UV light sources and specific visible wavelengths depending on the polarization state can also be used in glasses and windows to protect eyes and skin by blocking UV rays from sunlight."*

Here's hoping that these studies benefit data storage and encryption techniques and find applications in not only portable devices but also various optical and electronic components in the future!

Reference

Title of original paper (1): Plasmonic Nanostructure Engineering with Shadow Growth
Journal (1): *Advanced Materials*
DOI (1): 10.1002/adma.202107917

Title of original Paper (2): Plasmonic Nano-Rotamers with Programmable Polarization-Resolved Coloration
Journal (2): *Advanced Optical Materials*
DOI (2): 10.1002/adom.202301730

About the institute

The Gwangju Institute of Science and Technology (GIST) is a renowned research-oriented university in Gwangju, South Korea, with a primary focus on science and technology disciplines. Established in 1993, GIST has evolved into one of South Korea's leading institutions for higher education and cutting-edge research. GIST was ranked 96th in the world in the Engineering & Technology category of the Times Higher Education World University Rankings for 2014–2015, and is a member of a consortium of research-oriented universities, which includes GIST-KAIST-UNIST-UST-POSTECH-DGIST.

Website: https://www.gist.ac.kr/en/main.html

About the authors

1. Jang-Hwan Han is a Postdoctoral Fellow at the Gwangju Institute of Science and Technology (GIST). He received an M.Sc. in information and communication engineering from Inha University and a Ph.D. in materials science and engineering from GIST. During his Ph.D., he developed magnetically active optoelectronic devices including light-emitting diodes, photovoltaics, displays, and sensors. He has recently expanded his research domain into nanophotonic devices for active metamaterials, plasmonic displays, and nanorobotic applications.

2. Doeun Kim is a Ph.D. student at the School of Electrical Engineering and Computer Science, Gwangju Institute of Science and Technology (GIST). She received her B.Eng. and M.Eng. degrees in materials engineering and convergence technology, respectively, from Gyeongsang National University (GNU). She was an Assistant Researcher at the Electronic Convergence Materials Division, Korea Institute of Ceramic Engineering and Technology (KICET) for 3 years. Her research interests include 3D nanofabrication, biophotonic metasurfaces and metamaterials, and super hydrophobicity.

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5. Hyeon-Ho Jeong is an Assistant Professor at the Gwangju Institute of Science and Technology (GIST). He received B.Eng. and M.Eng. in electrical engineering from Dankook University and a Ph.D. in materials engineering from Max Planck Institute for Intelligent Systems and EPFL. Before joining the GIST, he was a research associate at the Cavendish Laboratory, the University of Cambridge for 1.5 years. He was awarded the Graduate Student Awards in 2016 from MRS (Gold) and in 2017 from EMRS for research in the field of material science. He has research interests including micro and nano robotics, chirality, plasmonics, and metamaterials.