Mechanical engineer's method to control growth of carbonate-based crystals featured in PNAS

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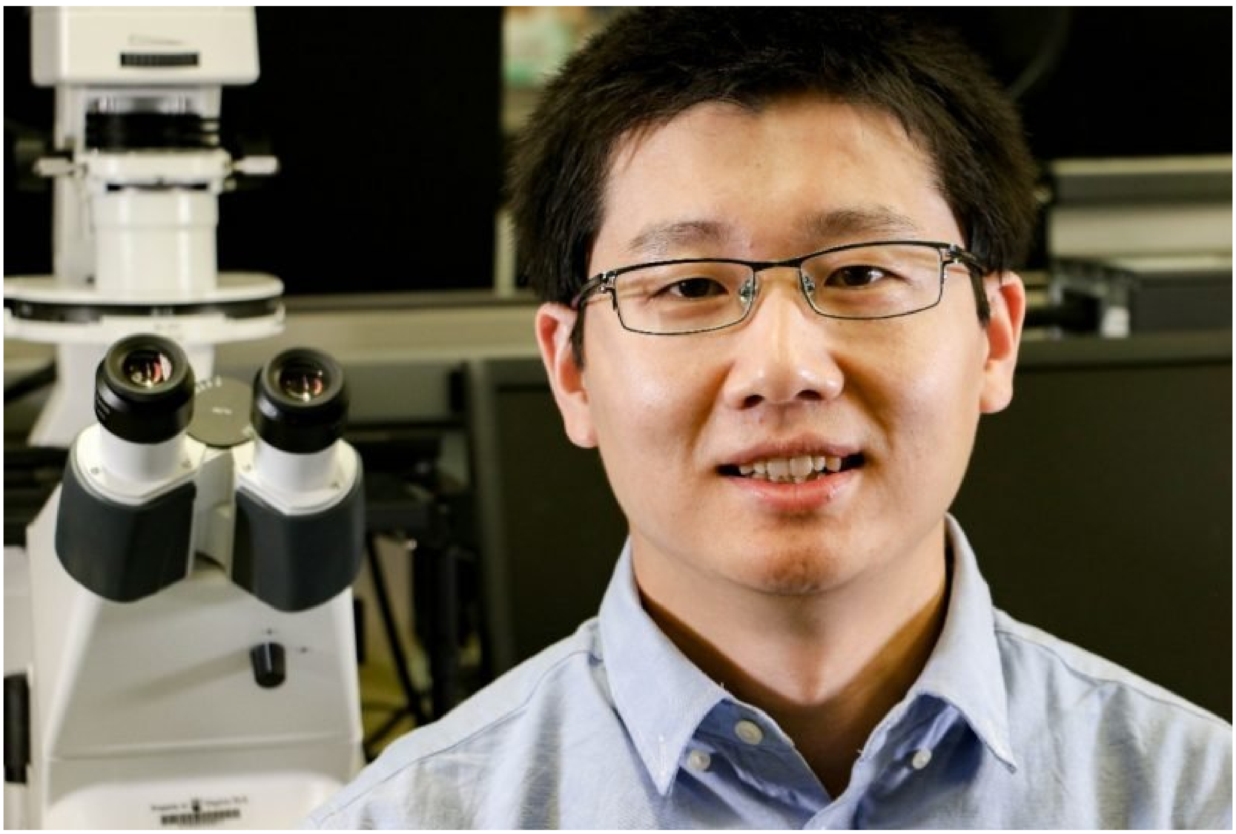

Ling Li, assistant professor of mechanical engineering in the College of Engineering. Credit: Virginia Tech

Growing crystals just got a little easier thanks to work by an international team from Virginia Tech, Harvard University, and AMOLF, operated by the Foundation for Fundamental Research on Matter Institute AMOLF) in Netherlands.

The team included Ling Li, assistant professor of mechanical engineering in the College of Engineering.

The group's work recently appeared in the journal *Proceedings of the National Academy of Sciences* (*PNAS*) with Li as the first author. Research on controlled nucleation and growth of crystals will provide insights for understanding, mimicking, and ultimately expanding upon nature's strategies of mineralization for developing functional microscopic structures.

The growth of crystals has been an important part of trying to mimic biological mineral formation as biomineralized structures in nature, such as seashells and bones, which are far more durable and advanced than those created synthetically today. Using one of two control parameters, super-saturation or nucleus lattice mismatch, researchers could control the nucleation and growth of carbonate-based crystals.

"Our research has successfully combined both local super-saturation and lattice mismatch to more effectively promote crystal nucleation," said Li. "By demonstrating control over both parameters we can direct the positioning and growth direction of crystalline compounds on specific substrates."

Substrate/nucleus lattice mismatch refers to the difference of crystal alignment between the growing crystal on a particular substrate, while local super-saturation indicates the concentration of the dissolved material around a growing crystal structure immersed in solvent is greater than its solubility limit.

"The motivation of this work is to understand how biological mineralized structures form – such as seashells," Li said. "A seashell is primarily made of chalk, which obviously is brittle and weak, but nature organizes the structure in such a way as to make it very strong."

The collaborative research group is working to explain the key structural basis of the mechanical properties and understand their formation pathways for the development of bio-inspired structural materials in the future.

Li's part of the project focuses on the interfacial structures between underlying substrate and overgrown crystals and how structures can grow differently on different conditions.

Using an example of three different crystalline structures of calcium carbonate (the most abundant biominerals found in nature) as substrates, the team determined that by modifying the location of the crystallization reaction that takes place in a solvent, they could affect both super-saturation and substrate/nucleus lattice mismatch and in that way, nucleate and direct the growth of the crystals in a specific location and direction.

"By trying to understand how these structures are organized, we can attempt to mimic nature with synthetic materials and improve the mechanical properties," said Li.

One of the next steps in the research will have Li leading the same group as they observe how the crystals form under an X-ray beam that will record the entire growth process.

"We want to watch how crystals grow at a nano-meter resolution, to provide more insight in terms of understanding how the growth parameters control the morphology of the crystals, and perhaps more insight into how biological systems work to control morphology, which is extremely important in terms of their properties."

More information: L. Li et al. Directed nucleation and growth by balancing local supersaturation and substrate/nucleus lattice mismatch, *Proceedings of the National Academy of Sciences* (2018). DOI: 10.1073/pnas.1712911115

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