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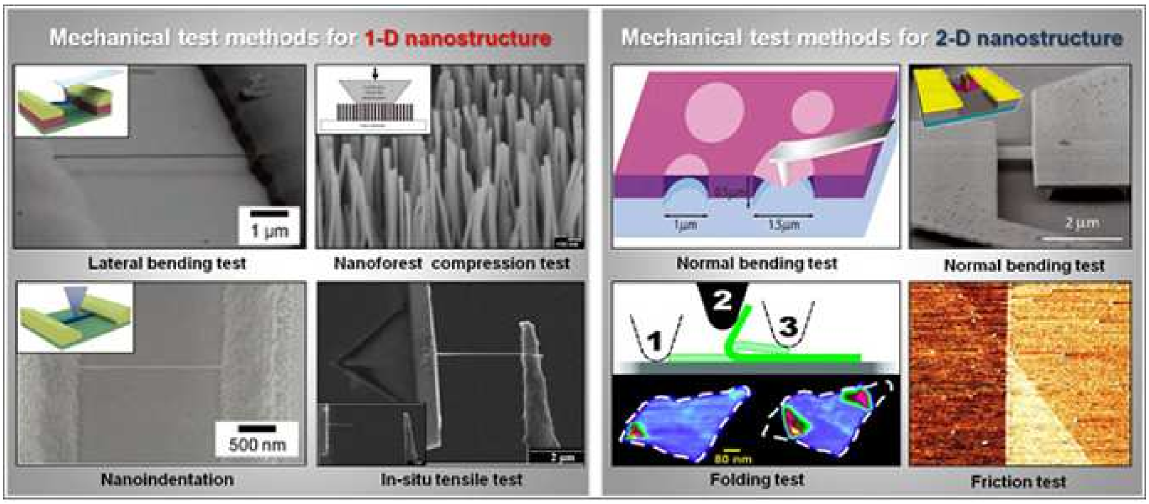
Exploring Nanoscale Mechanical Behavior

Professor Jae-il Jang (Division of Materials Science & Engineering)
"Attitude is the key to a good researcher."

Professor Jae-il Jang of the Division of Materials Science and Engineering selected as the researcher of the month is both a researcher and director of the 'Nano-/Micro-Mechanical Behavior Lab'. His research group has developed both experimental and theoretical approaches towards a better understanding of the mechanical behavior of materials at various scales from macro to nano. His recent research focuses on the nano-mechanical behavior of novel materials such as bulk metallic glasses (BMGs), high entropy alloys (HEAs), nano-crystalline-/nano-twinned (NC/NT) metals, and ultrafine-grained (UFG) metals, and ultra-high-strength steels through development of novel nano-mechanics testing techniques.

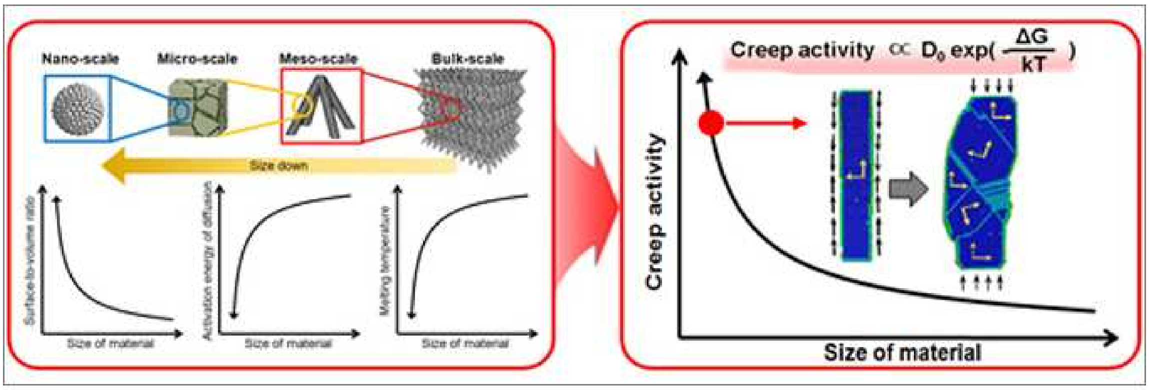
The successful utilization of materials requires that they satisfy a set of properties such as mechanical, physical, chemical, optical, and thermal properties. Among them, mechanical properties are essential for the achievement of sustainability and reliability of the materials, and have long been actively researched as a hot issue of the materials research community. Recent research of Jang's group mainly concentrates on the mechanical behavior and properties at micro-meter or nano-meter scale where the material shows completely different nature of the properties from its normal states.

Conventional mechanical testing methods such as the uniaxial tensile/compression test, three-point bending test, and hardness test are not suitable for or applicable to the mechanics of nanoscale materials, and no established and standardized methods are currently available for these new issue. Thus, main challenges in the experimental study on nanoscale mechanical properties include: (1) controlled synthesis, manipulation and positioning of specimens with nanometer accuracy; (2) application and measurement of forces in the nano-Newton level, and (3) measurement of mechanical deformation with nanometer resolution. Jang's group has also made much effort to solve this issue, and have found many robust methods.



Testing of 1D / 2D nano-materials is critical in estimating mechanical properties but the method of testing should be more developed.

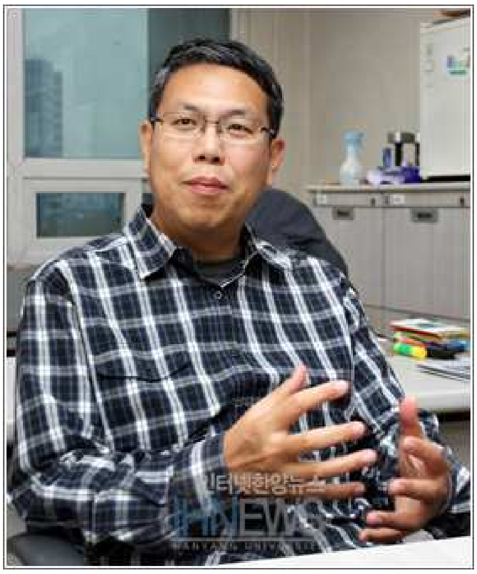
These methods are one of the most active research topics in his group and is so-called "nanoscale room temperature creep (nano-creep)." Generally, materials can experience time-dependent plastic deformation (creep) when they are exposed to low-level stresses at relatively high temperature for a long time. However, his group expects that materials at the nanometer scale would exhibit the unique creep behavior, i.e., nano-creep, distinctively different from their bulk counterparts. Specifically, it is predicted due to the following reasons: one of the main mechanisms for creep is diffusional flow of atoms and/or vacancies, and surfaces provide the most efficient diffusion pathway. Therefore, creep behavior can be accelerated in nanomaterials with high surface-to-volume ratio (SVR). In nanomaterials, the number of surface atoms becomes a significant fraction of the total number of atoms. Atoms located at or near the surface of the nanomaterials have reduced cohesive energy due to a reduced number of cohesive bonds. Consequently, reduction in melting point with a decrease in the size of a nanomaterial can affect significantly on time-dependent mechanical behavior at a given temperature. Based on above trend, the reduction in activation energy for the diffusion creep (i.e., creep by diffusion of atoms/vacancies) in nanomaterials may enable their creeping at room temperature.



The increase in nano-creep activity could be widely utilized in next-generation devices such as flexible/curved products, and increasing its lifetime of usage.

This nano-creep research can be applied to various mechanisms in the future. For example, with rapid advances in the nanomaterial-based 'flexible/stretchable/curved' devices and better understanding of the creep behavior of the nanomaterial components in the devices under long-term external stresses, it would be possible to ensure the reliability and lifetime of the devices.

Among different research targets in his research group, Jang does have his own criteria over traits of chosen research. Jang's primary frame for deciding what to research is interesting and applicable research. "The efficiency of research increases when the topic itself is fun and clear to the members of the group." says Jang. To his graduate students, Jang always emphasizes that having a good research attitude is more valuable than a super-smart brain, especially for those who aim to become engineers. "To be good engineering researchers, we don't need to be Einstein. It is more important to have a good engineering research attitude that means the sincerity and the mind prepared for teamwork." said Jang. "The two important minds for teamwork are," he continued, "having responsibility for his/her own role and being thoughtful to other team members."



Among many requirements of researchers, Jang emphasizes the importance of sincerity and preparation for the research.

Read in Korean

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Other articles written by this reporter

Photo by Yumi Jo