In situ property measurement of inorganic nanomaterials under TEM

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Understanding the mechanical properties of inorganic nanomaterials is not only fundamentally interesting but also practically important, because of their broad applications, ranging from energy storage to composite materials, where the mechanical properties will determine the structural reliability and long-time performance. In situ transmission electron microscopy (TEM) is unique for probing mechanical properties at nanometer scale, simultaneously enabling manipulation at sub-nanometer precision, quantitative mechanical measurement with nanonewton accuracy, and deformation mechanisms at atomic resolution.

In my talk, I will present our recent works on the mechanical properties of inorganic nanomaterials by applying the in situ TEM method.(1) In addition to the intrinsic chemical bonding and famous size effects, we investigated the influences of the "microstructures" and external loading conditions. Due to an interlocked joint geometry, the deformation mechanism of bamboo-shaped BNNTs was switched from an interplanar sliding mode to an in-plane tensile elongation mode, with tensile strength up to 8.0 GPa.(2) Due to the different stress states, Si nanowires showed distinct deformation behaviors under tension and bending. Under tension, Si NWs deformed elastically until brittle fracture. Under bending, the Si NWs demonstrated considerable plasticity, with a crystalline-to-amorphous phase transition.(3) Due to the surface energy, the bending behaviors of MoS_2 atomic layers demonstrated strong size dependence, from spontaneous rippling (<5 atomic layers) to homogeneous curving (~10 layers) and to kinking (>20 layers).(4) Our work has greatly enriched the understanding of mechanical properties of inorganic nanomaterials and offers valuable guidelines for the design of mechanically reliable nanodevices.

References

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Education

1975	Ph.D, Graduate School of Science, Inorganic Chemistry, Osaka University

Professional Experience

1975	Researcher at National Institute for Research in Inorganic Materials (NIRIM)
1979	Visiting Scientist, Arizona State University, USA
1993	Adjunct Professor of the Institute of Materials Science, University of Tsukuba
1996	Supervising Researchers, Advanced Beam Analysis Station, NIRIM
2001	Director of the Integrated Strategy Office at National Institute of Materials Science (NIMS)
2003	Director-General, International Center for Young Scientists (ICYS), NIMS
2004	NIMS Fellow
2007	Chief Operating Officer (COO), MANA, NIMS
2008	Visiting Professor, Waseda University

Fields of Research

He has been working on "Synthesis and property measurements of novel 1D/2D nanomaterials such as BN nanotubes and nanosheets". He has succeeded in producing high purity and large scale BN nanotubes. He has received a number of awards including the 3rd Thomson Reuters Research Front Award (2012) and the 16th Tsukuba Prize (2005). He has been selected as ISI Highly Cited Researchers in Materials Science (2014). He is now an adjunct member of the Science Council of Japan and also a Fellow of The American Ceramic Society.

Selected Recent Publications:

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