3rd Korea-US NanoForum, Seoul, Korea, April 3-4, 2006

Efforts in Improving the Force and Displacement Resolution to Explore the Nano-World

Chung-Seog Oh*, Hak-Joo Lee, Kiho Cho**, Jae-Hyun Kim****

*Kumoh National Institute of Technology
1 Yangho-dong, Gumi-si, Gyeongbuk, Rep. of Korea
ocs@kumoh.ac.kr

**Korea Institute of Machinery and Materials
171 Jang-dong, Yuseong-gu, Daejeon, Rep. of Korea

ABSTRACT

The invention of the scanning probe microscope (SPM) marks an era in seeing the nano-world and leads enormous research topics. As the applications of nano-sized devices become more demanding, there is a need for accurate characterization of the mechanical properties of the invisible structures that are used in the devices. In addition, it is well known that a material's properties at the small scale are very different from those at the bulk scale. Force and displacement are among the most generic measured quantities in science and engineering to characterize the properties. However, it is very challenging for a mechanical engineer to measure those quantities accurately at the nanometer level. This paper aims at introducing our continuous efforts in improving the force and displacement measurement resolution with the SPM and laser interferometric nano extensometer (LINE®).

The rhombus-shaped SPM cantilevers capable of performing multi-functioning tasks such as indentation, strip bending and adhesion tests are fabricated by using single crystal silicon micromachining. The laser targeting surface of a cantilever fabricated by deep reactive ion etching (DRIE) only is not shiny enough to get sufficient light intensity and so a few μm wide areas slightly polished by focused ion beam (FIB). The force constants of cantilevers range from 5 to 240 N/m and the displacement resolution is normally 0.1 nm and thus the force resolution can be down to 0.5 nN, which is good enough to touch the nano-land. Some preliminary tests are performed to prove its usefulness in determining the mechanical properties as well as topographic imaging in nano-scale.

The accurate measurement of an in-plane displacement in a uniaxial tensile testing is very essential in evaluating the basic material properties such as Young's modulus, yield strength and tensile strength. The LINE® is an improved system from the interferometric strain/displacement gage (ISDG), which is originally developed by W. N. Sharpe, Jr. The brand new system is applied in measuring the coefficient of thermal expansion (CTE) for the 1 μm thick aluminum nitride (AlN) specimens. The in-plane displacement resolution is about 5 nm at the best circumstances.

We can see the nano-world by an SPM, apply and measure the force by the rhombus-shaped cantilever, and measure the distance by the LINE® but these techniques leave much room for improvement.