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[1] Regazzoni et al, Acta Materialia, 35(12),1987.

IMPORTANCE OF DYNAMICS IN SMALL SCALE MECHANICAL TESTING: FAST CONSTANT STRAIN RATE AND BALLISTIC TESTING

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Recent advances in electronics have enabled nanomechanical measurements with very low noise levels at fast time constants and high data acquisition rates. Nanomechanical testers with sub-nanometer noise levels at a displacement time constant of 20µs are currently available which open the doors for a wide range of ultra-fast nanomechanical testing. It not only enables accurate measurement of materials' response during a dynamic event such as strain burst (pop-in) during micropillar or indentation testing, but also enables fast indentation tests. However, fast testing requires a precise understanding of the instrument's dynamic response along with the time constants of the measurement signals.

One of the novel experiments that can be performed using a system with fast time constants is the constant high strain rate indentation test. This enables generating four dimensional (4D) mechanical property maps, wherein the hardness and modulus are measured as a function of depth and the spatial location. Results from such high speed 4D mapping of a silica grating on silicon substrate with each indentation taking less than 3.5 seconds will be presented as shown in the figure below. This is a very powerful tool for mapping the mechanical properties of integrated circuits including sub-surface features.

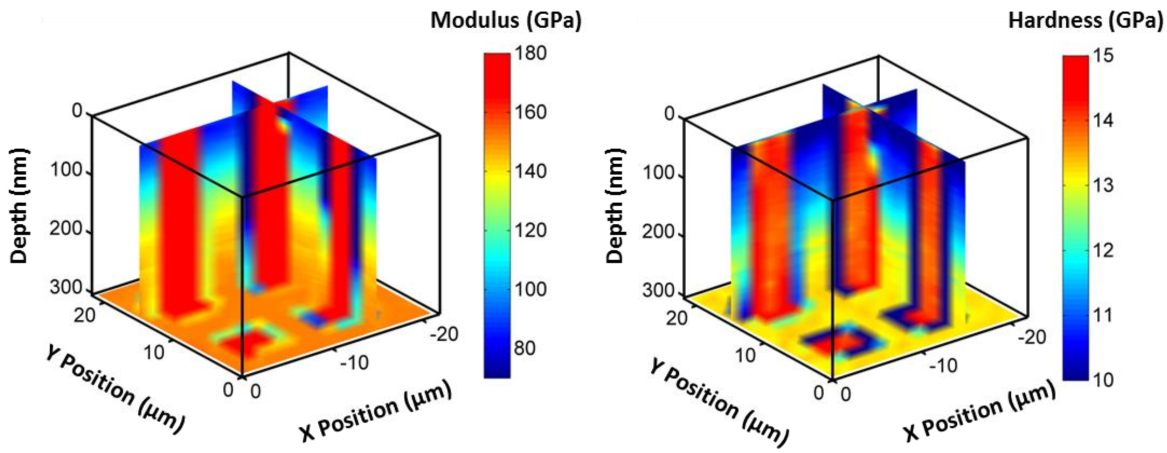

Figure 1 – High speed 4D maps of hardness and modulus of silica grating on silicon substrate

Another area of small scale testing that greatly benefits from current advancements in nanomechanical testing instrumentation is the rate dependence of strength. One of the major limitations of the current methods to measure the strain rate sensitivity by indentation over any significant range of strain rates is the lack of access to high strain rates. With an accurate dynamic model and an instrument with fast time constants, step load tests can be performed which enable access to indentation strain rates ($\dot{h}$ / h) approaching ballistic levels (> 1000 s^{-1}). Results from high strain rate testing on aluminum and tin will be presented and compared to the results from Split Hopkinson bar experiments for fcc metals [1]

[1] Regazzoni et al, Acta Materialia, 35(12),1987.