

# NIST National Measurement System Assessment

## Measurement Need Datum (MN)

**Technology at Issue:** Top Down Micro/Nano Manufacturing

**Submitter(s):** Nicholas G. Dagalakis

**Technological Innovation at Stake:** A central challenge of micro/nano manufacturing is the development of methods to build complex three-dimensional (3-D) micro/nano scale structures and devices using techniques that allow them to interface with the macro scale world (scale-up). Top down nano manufacturing refers to human-directed organization of nano scale components into structures, which must then interface with the macro scale world through some kind of scale-up interface. Top down manufacturing of these devices must be explored and standardized in order to allow for the economies of scale needed for successful production.

**Economic Significance of Innovation:** This is an enabling technology, which can affect the development of markets in many new classes of products, which require accurate nano component 3-D position and orientation. For example this technology can accelerate the production of nano component, electronics, composite materials, sensors, fuel cells, etc. According to a Lux Research report, the nano technology products market could reach \$2.6 trillion in approximately 10 years. Assuming this infrastructure gets put in place, an estimated 10 million manufacturing jobs worldwide – or about 11% of the total manufacturing jobs – may involve nano technology in that time frame. According to a SusChem report the nano technology machinery market is expected to grow by 30% per annum.

**Technical Barrier to the Innovation:** Integration of micro and nano systems over multiple length scales ranging over orders of magnitudes is a challenge that must be met. Many factors make up this challenge, including: raw material supply and product transport, precise and inexpensive arrays of fast parallel 3-D human directed manufacturing cells, massive parallel controls, sensors, fast imaging, scale-up interfaces. Manipulation, placement, actuation, and packaging of nano devices such as nano tubes, nano particles, or single molecules is a largely unexplored area.

**Stage of Innovation Where Barrier Appears:** R&D (primary), Production (secondary)

**Measurement-Problem Part of Technical Barrier:** Fast and precise positioning and manipulation require accurate mathematical models, force, position and velocity sensing. Due to design required fabrication process variations, it is necessary to know mechanical properties of materials and the shapes of surfaces and features in hard to reach places, at different locations and orientations of a die. Since contact of fast moving objects might be necessary, it will be required to know the tribological, static friction, and wear properties of the materials involved.

**Potential Solutions to Measurement Problem:** Develop micro/nano sensors that can be embedded into fast moving devices. Develop compact models using controlled physical signals as input and material mechanical properties of dies at different positions and orientations as output. Identify nondestructive measurement methods for the shape of surfaces and buried structures.

**Potential Providers of Solutions:** Due to the multifaceted nature of the problem, which involves basic research, expensive prototype testbeds, and standards, it will most efficiently be addressed by industrial, academic and government laboratories research groups working together.

**What is the role for Government, if Any?:** Build high quality prototype testbeds, tools and measurement techniques, which will be available to academia and industry for testing and experimentation. Provide leadership and technology transfer to standards writing organizations and industry.

**If There is a Government Role, Why Industry Says It Can't/Won't Pay for That Part of Solution:** This is a broad technology, not specific to any one industry, which promises to benefit several product markets, like electronics, composite materials, sensors, fuel cells, etc. Therefore, it will be difficult for a single company to have the incentives and the funds to develop the necessary metrology and standard needs.