

## **Nano-indentation Behaviour of Ultrathin Polymeric Films**

**Syed Vajib Ali.H<sup>1\*</sup>, Nagamani.A<sup>2</sup>, Yeshwanth.A<sup>3</sup> and Sundaram.S<sup>4</sup>**

*Aeronautical Department, Park College of Engineering and Technology, Coimbatore.  
\*Associate Professor, Aeronautical Department,  
Park College of Engineering and Technology, Coimbatore.*

### **Abstract**

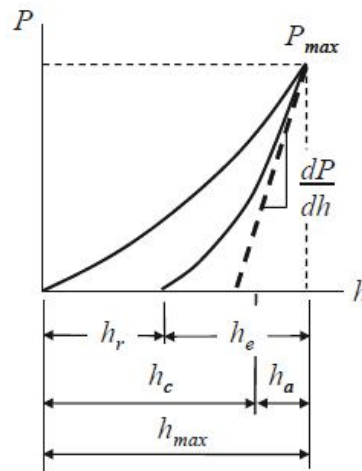
Nano-indentation is a versatile technique used for studying the mechanical properties of thin films on substrate. Depth-sensing Nano indentation technique provides a continuous record of variation of indentation load with penetration depth into the specimen and this technique has high resolution even at low load scale. Currently, the Nano indentation technique is being applied to determine hardness and Young's modulus. This project deals with the methodology that uses finite element modeling to characterize the mechanical properties of ultrathin polymer films.

### **1. Introduction**

Nano indentation testing is the indirect measurement of the contact area i.e., the area of contact between the indenter and the specimen. It is a Method of touching the material of interest whose mechanical properties are unknown with another material whose properties are known. It is an indentation test in which the depth of penetration is measured in nanometres. Indentation testing is a simple method that consists essentially of touching the material of interest whose mechanical properties such as elastic modulus and hardness are unknown with another material whose properties are known. Since it is in nanometres the process is considered as a non-destructive process.

### **2. Methodology**

An indenter usually a Berkovich type is placed in contact with the flat surface of the specimen with a steadily increasing load. Both load and depth of penetration are recorded at each load.



**Fig. 2.1:** Load vs. Displacement graph.

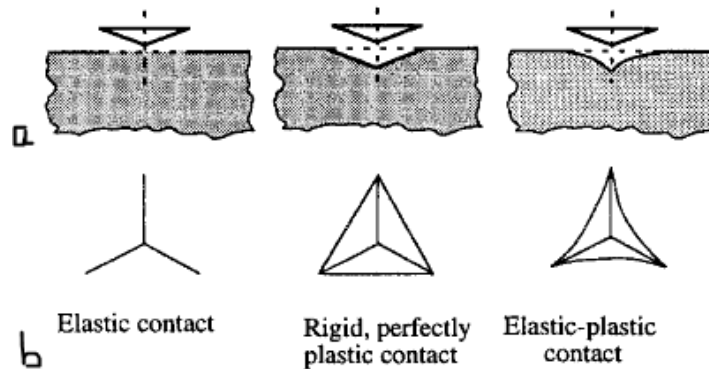
Following the attainment of the maximum load, the load is steadily removed and the penetration depth recorded. The loading part of the indentation cycle may consist of an initial elastic contact, followed by plastic flow, or yield within the specimen at higher loads.

Upon unloading, if yield has occurred, the load-displacement data follow a different path until zero applied loads are reached and residual impression is left in the specimen surface. The maximum depth of penetration for a particular load, together with the slope of the unloading curve measured at the tangent to the datapoint at maximum load, lead to a measure of both hardness and elastic modulus of the specimen material. In some cases, it is possible to measure elastic modulus from not only the unloading portion, but also the loading portion of the curve.

The methods of analysis of Nano indentation test data rely heavily on the elastic unloading response of the system.

The following assumptions are important for the derivation of analytical equations:

- The radii of curvature of the contacting bodies are large compared with the radius of the circle of contact.
- The dimensions of each body are large compared with the radius of the circle of contact. This allows indentation stresses and strains to be considered independently of those arising from the geometry, method of attachment and boundaries of each solid.
- The contacting bodies are in frictionless contact. That is, only a normal pressure is transmitted between the indenter and the specimen.



**Fig. 2.3** showing.

- a) Deformed surfaces after tip removal.
- b) Residual impressions of indentation for ideal elastic, rigid perfectly-plastic and elastic-plastic.

### 3. Finite Element Method Analysis

#### 2.1 ANSYS general structure:

There are three main steps in a typical ANSYS analysis:

##### Model generation:

- Simplifications, idealizations.
- Defining materials and their properties.
- Generation of finite element model (meshing).

##### Solution:

- Specifying boundary conditions.
- Obtaining the solution.

##### Review results:

- Plot/list results.
- Check for validity.

### 4. Conclusion

From the final indentation depth and the projected area of the deformed region, hardness of the material can be found out. The Nano indentation analysis is carried out for only a single data set.

For thin film layers with different yield strengths, the final indentation depth and the projected area of the deformed region will be different and hence the Young's modulus and hardness values will be different for these materials.

The curvature in the unloading data can be accounted for by assuming that the indenter behaves as a punch whose geometry is such that the contact area changes continuously during unloading. It is also observed that thin film mechanism properties are different from bulk material.

## **References**

- [1] Anthony C.Fisher-cripps “Nano Indentation” Springer.
- [2] The Finite element method and applications in Engineering using ANSYS by Erdogan Madenci and Ibrahim Guven.