

# FINITE ELEMENT ANALYSIS OF NANOINDENTATIONS

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## INTRODUCTION

### ◆ Motivation

- ◆ Organic fibers (e.g., Kevlar) have distinct orientational material gradients within the fiber. The small diameter of these fibers makes it hard to establish the mechanical properties. Thus, nano-indentation will be used. Whereas these tests are relatively easy to perform, they are hard to evaluate.

### ◆ Objectives

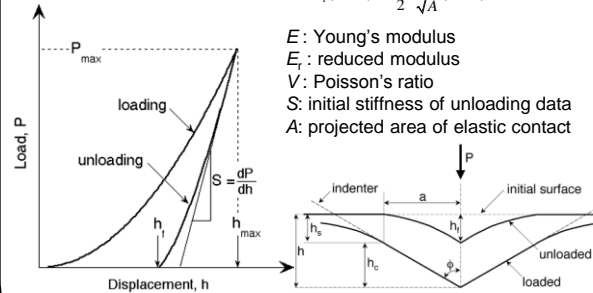
- ◆ Finite element analysis (FEA) of nanoindentation on semi-infinite solid and sphere
- ◆ Nanoindentation experiments on PMMA and fused silica and in comparison with FEA
- ◆ Parametric studies on contact geometry and material properties

## OLIVER-PHARR METHOD

- ◆ Analytic method to calculate the Young's modulus and hardness of a material using unloading curve of indentation

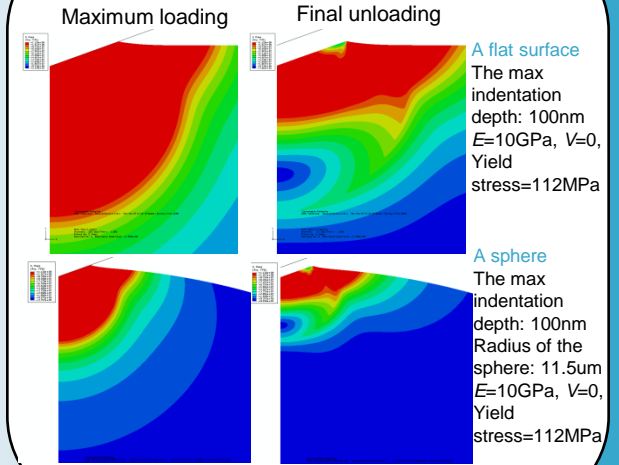
$$E = E_r(1-\nu^2) = \frac{\sqrt{\pi}}{2} \frac{S}{\sqrt{A}}(1-\nu^2)$$

$E$ : Young's modulus  
 $E_r$ : reduced modulus  
 $\nu$ : Poisson's ratio  
 $S$ : initial stiffness of unloading data  
 $A$ : projected area of elastic contact

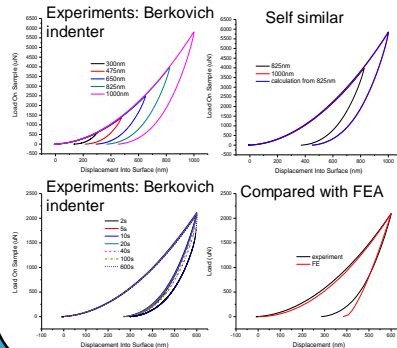


Oliver WC, Pharr GM. An improved technique for determining hardness and elastic modulus using load and displacement sensing indentation Experiments. J Mater Res, 1992;7(6): 1564-1583.

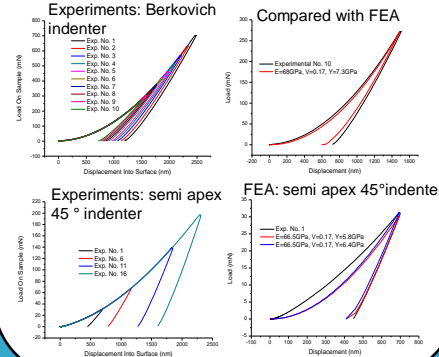
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## NANOINDENTATIONS ON PMMA



## NANOINDENTATIONS ON FUSED SILICA



## SUMMARY AND FUTURE WORK

- ◆ The simulated loading and the upper portion of the unloading curve of PMMA can match the experimental curve; to capture the lower unloading curve, time-dependent simulations may be needed.
- ◆ The simulated loading and unloading curves of fused silica can closely match the experimental curve
- ◆ 3D FE model will be used to simulate nanoindentations on glass fiber

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