The influence of moisture content on mechanical properties of wood cell wall by nanoindentation

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Outline

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- **Introduction**
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  - *Presentation on nanoindentation*
- **Objectives**
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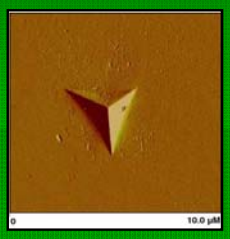
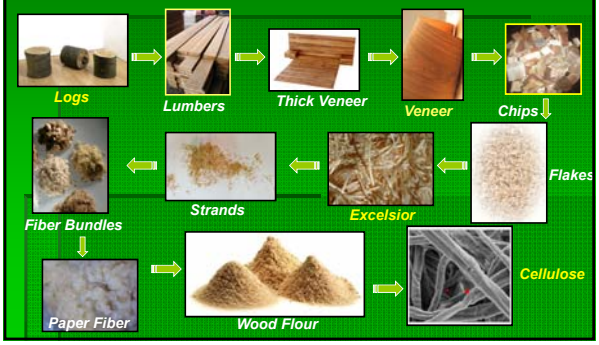
  - *Specimen preparation*
  - *Relative humidity control*
  - *Nanoindentation load function*
- **Preliminary Results**



Background

-From Macro to Micro



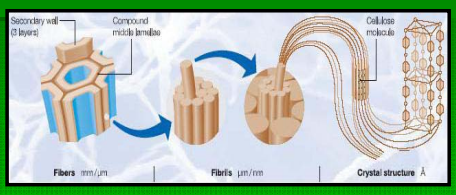
Problems?

Why micro study is important and difficult for wood?

- Difficulty of specimen preparation
- Lack of research on the mechanical properties of wood cell on small scale due to the limitation of experiment facility

Introduction

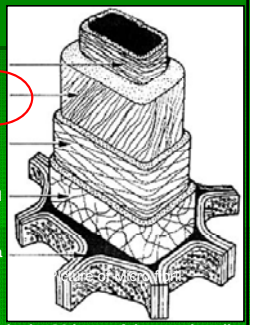
-Wood Structures



***Fiber** --- fine, threadlike piece, range from µm to mm in diameter*
***Fibril** --- a very slender thread-like structure that fibers are composed of, approximately 1 µm in diameter*
***Microfibril** --- a fine thread of cellulose in a cell wall, which is exceedingly small visible only at the high magnification of the electron microscope*
***Elementary Microfibril** --- the smallest fibril or unit in cell wall, 3-5 nm in diameter, also called nanocrystal or whisker*

Introduction

- Cell Wall Structure

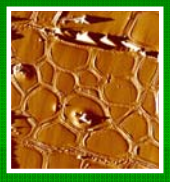


There is a strong belief that the microfibril angle in the S2 layer of the woody cell wall is a critical factor in the mechanical behavior of wood (Megraw, 1986).

Introduction
-Nanoindentation Scanning

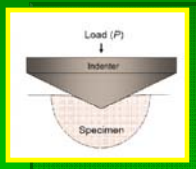
Hysitron Triboindenter

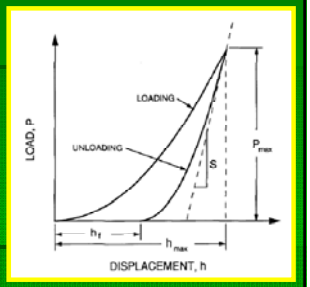
Topography



XY resolution: 20nm
Scan size =50 μm
Scan rate = 1.0 Hz
Integral gain = 496
Set point = 1.5 μN

Introduction
-Nanoindentation





Hardness- $H = \frac{P}{24.5h_c^2}$

Modulus- $E^* = \frac{dP}{dH}\frac{1}{2h_c}\frac{1}{\beta}\sqrt{\frac{\pi}{24.5}}$ $\frac{1}{E^*} = \frac{1-\upsilon_i^2}{E_i} + \frac{1-\upsilon_s^2}{E_s}$

Objectives

1. Sample preparation – set up a series of normative, well-suited methods for nanoindentation on wood cell wall
2. Measure the change of hardness and elastic modulus in wood cell under different moisture contents
3. Measure the hardness and elastic modulus of wood cell wall in liquid environment (water, acid, alkali)

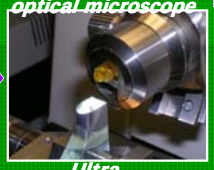
Materials & Methods

- Specimen Preparation

Materials: Yellow pine, red oak, poplar, white oak,

Wood cell under optical microscope

Wood Block



Ultra

Methods

- Relative Humidity Control

Desiccator

Saturated salt

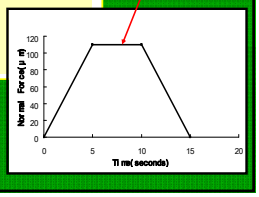
Salt Solution	Formula	RH(%)
Lithium chloride	LiCl	11.3
Magnesium chloride	$MgCl_2 6H_2O$	32.8
Potassium carbonate	K_2CO_3	43.2
Sodium bromide	NaBr	57.6
Ammonium chloride	NH_4Cl	78.0
Potassium chloride	KCl	84.3
Under water / acid / alkali		

Methods

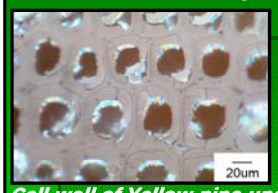
-Nanoindentation Load Function

1. ***Approach to the sample surface***
2. ***Scan the selected area and find the perfect cell wall***
3. ***Load to peak load in 5s***
4. ***Hold peak load for 5s***
5. ***Unload completely in 5s***

Reduce the cre



Preliminary Results

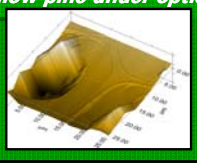


Cell wall of Yellow pine under optical microscope

Residual indent of yell

Plastic deformatio

3D image



Significance

a) Method development and improvement
b) Best explanation for macro phenomena
c) Micro mechanical properties of wood under similar circumstance to live condition (different moisture content and under liquid environment)

Acknowledgement

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Thank you for your attention!

Question?