

# An Introduction to Polymer Physics

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## Why & What

- Why do you choose this course?
- What do you know about polymer (physics)?

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## Physics

- Physics (**Greek: physis** – meaning "**nature**") is a **natural science**; it is the study of **matter** and its **motion** through **spacetime** and all that derives from these, such as **energy** and **force**. More broadly, it is the general analysis of **nature**, conducted in order to understand how the **world** and **universe** behave.

From Wikipedia, the free encyclopedia

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## Polymer physics

- Polymer physics is the field of **physics** associated to the study of **polymers**, their fluctuations, **mechanical properties**, as well as the **kinetics of reactions** involving degradation and **polymerisation** of **polymers** and **monomers** respectively.

From Wikipedia, the free encyclopedia

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## Polymer physics

- However, it is not a clear description.
- In my opinion, polymer physics can also be defined as **the relationship between the structure and properties of polymer**.

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## 1. Introduction to the course

- 1.1 Polymer and scope of the book
- 1.2 The chemical nature of polymers
- 1.3 Some useful physical techniques

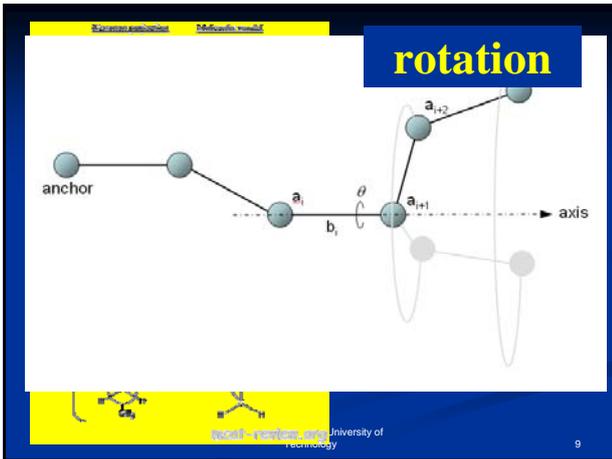
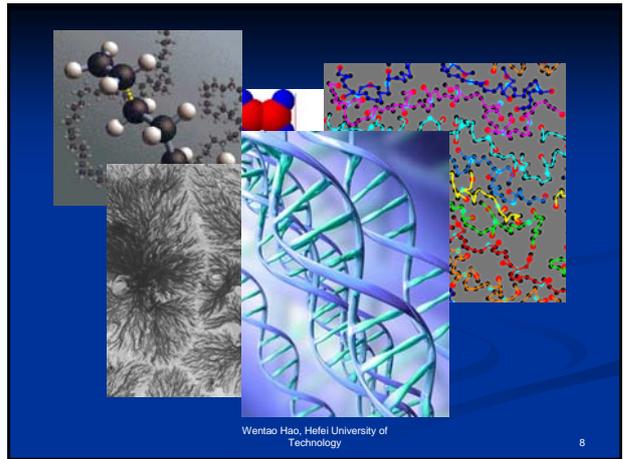
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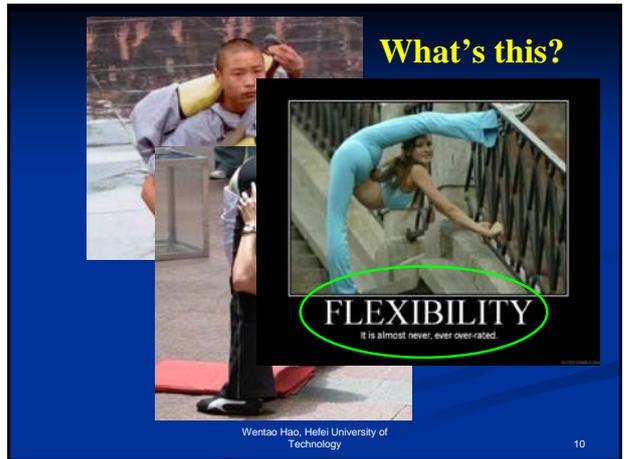
# 1.1 polymer and scope of the book

- What is polymer?
- Macromolecule
- Long chain
- Chemical bonds
- Rotation
- Flexibility
- Condensed state structure
- Molecular motion
- Mechanical performance
- .....

**diversity**



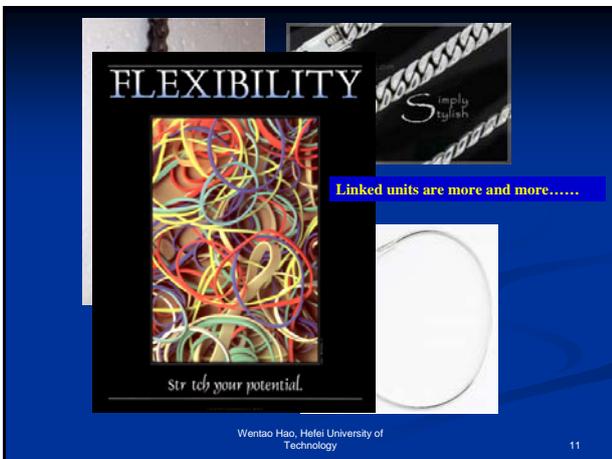
**rotation**



**What's this?**

**FLEXIBILITY**

It is almost never, ever over-rated.

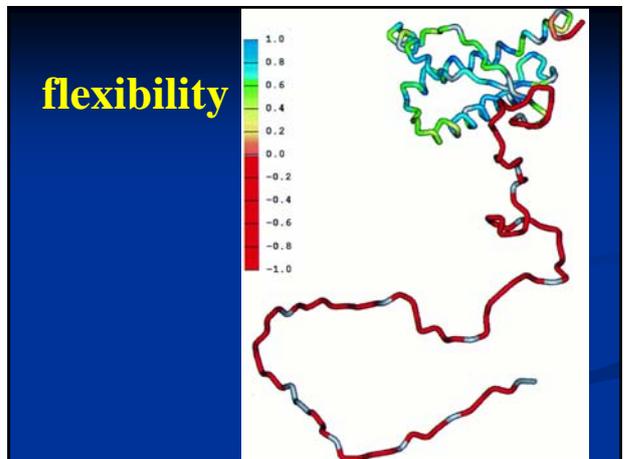


**FLEXIBILITY**

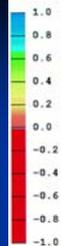


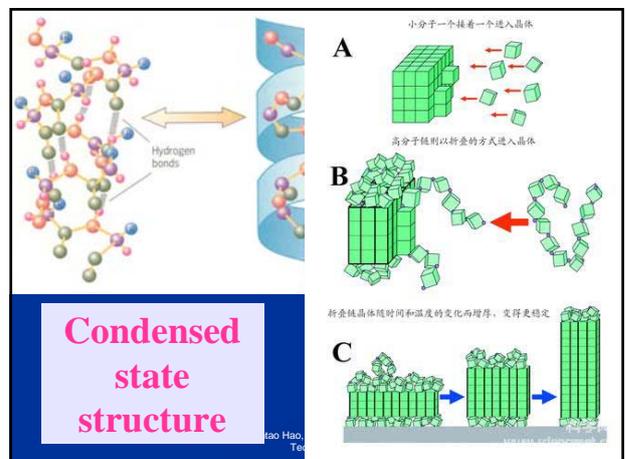
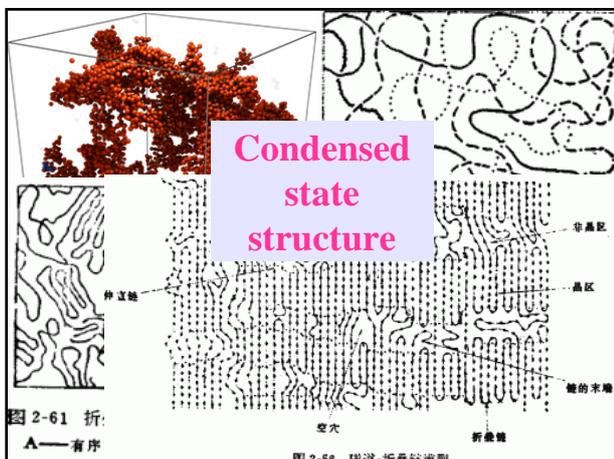
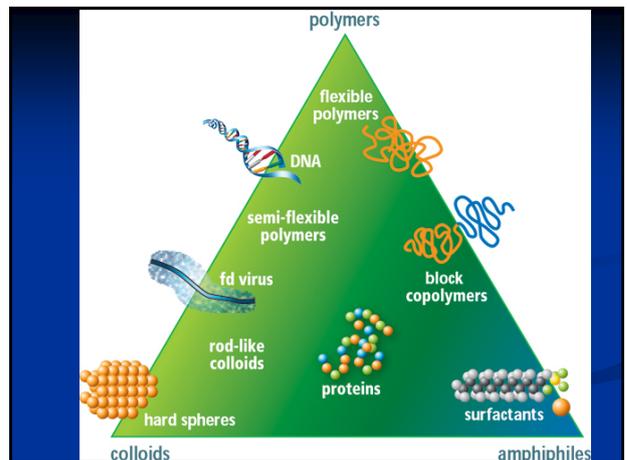
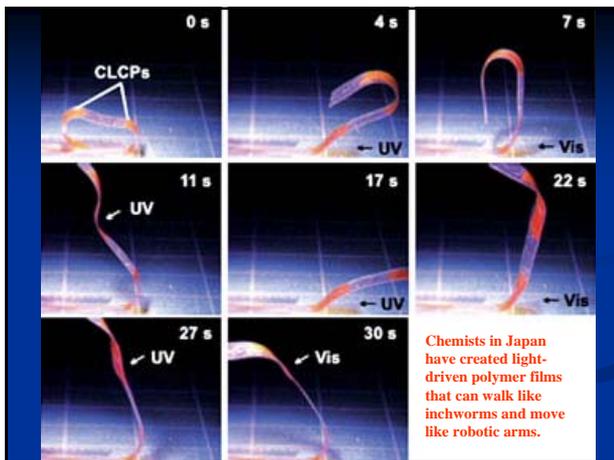
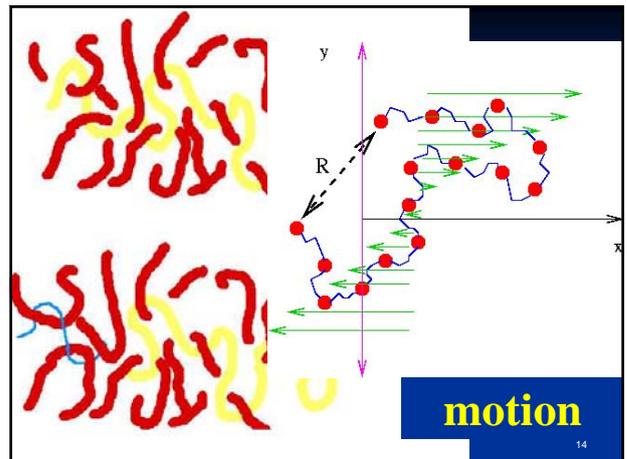
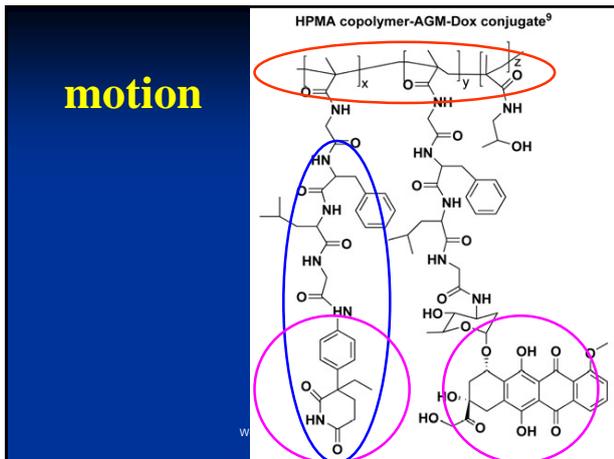
Stretch your potential.

Linked units are more and more.....



**flexibility**





The weapon is fed from translucent, double-column box magazines (molded from a high-strength polymer) with a 30-round capacity and an empty weight of 130 g (4.59 oz). The light machine gun version of the AUG uses an extended 42-round magazine.

**Mechanical performance**

**EAT, SLEEP, DO – POLYMER**

**Super absorbent polymer**

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**How to understand the diversity of polymers?**

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**1.2 classification of polymers**

**A. Classification based on structure**

**Monomers**

**Polymers**

**linear**

Technology

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**Branched**

**(a)**

**(b)**

**(c)**

$D_n$  ( $n = 14, 24, 42, 51$ )

$HB_n$  ( $n = 51, 79$ )

$Dona$  ( $n = 15, 46, 81$ )

**Branched**

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a: polyepichlorohydrin

b: ethylene oxide / polyepichlorohydrin copolymer

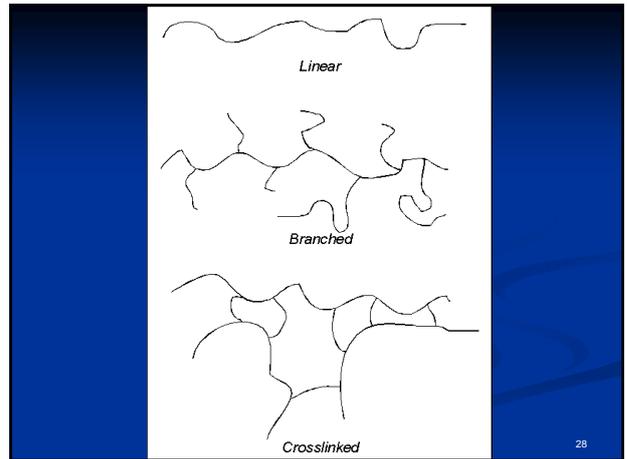
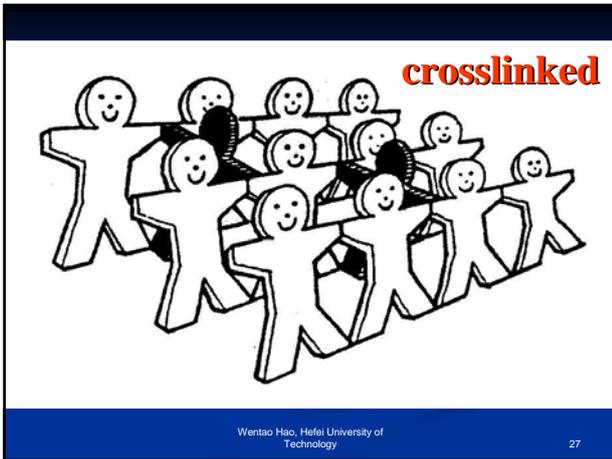
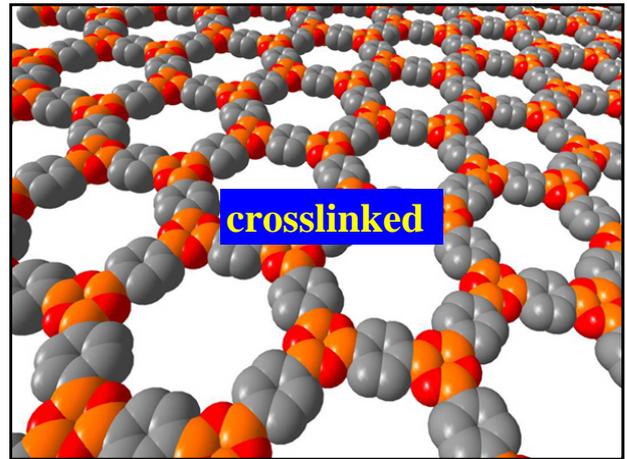
Statistics:

- a: 45 monomer units  
4 crosslinks  
crosslinks / fixed ion: ca 9%
- b: 22 monomer units  
2 crosslinks  
crosslinks / fixed ion: ca 9%

**crosslink**

**crosslinked**

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How Plastics Work — Polymers ©2007 HowStuffWorks

Copolymers #1 and #2

Monomer #1

Monomer #2

Homopolymers #1

Homopolymers #2

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**B. Classification**

**Thermoplastics**

- HDPE**: Bottles for detergents, milk and fuel jugs; Bottle caps and closures; Film packs for chips, biscuits.
- LDPE**: Bags, sacks, bin-liners, squeeze bottles; Bread bags; Frozen food.
- PVC**: Food trays; bottles for fruit juices and shampoos; blister packs for pills.
- PP**: Margarine tubs, squeeze bottles for ketchup, sauces; Bottle caps and closures; Film packs for chips, biscuits.
- PET**: Fizzy drink bottles, versatile sturdy meal containers, roasting bags.
- PS**: Egg cartons, yogurt pots; Bottle caps and closures; Food trays.

# So, what is the main feature of thermoplastics?

high performance **thermoset** composites

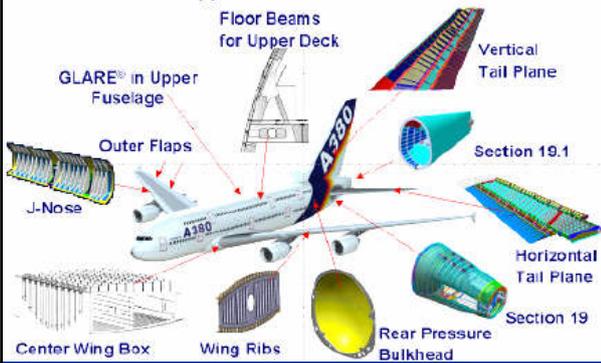


1950's **Thermoset** flower necklace with rhinestone centers



## Composite & Hybrid Materials

New / Advanced Application in A380



## Thermoplastic

Mold is cooled

Screw root is tapered

Two hoppers (resin & colorant)

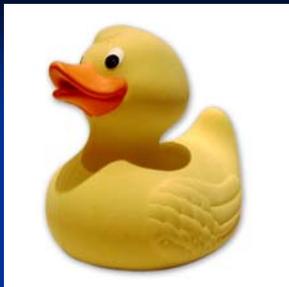
Mold is heated

Screw root is straight

One hopper (just resin)

## Thermoset

## Rubbers



## Rubber band gun



amorphous      crystalline      crosslinked

**thermoplastics**      **Thermosets or Rubbers**

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**LCP**

Needle-free syringe molded of Vectra® liquid crystal polymer

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Protective film, LPSAR Layer, AGHC Layer, TAC, PVA, TAC, UV film or Compensation film, PSA, Release film

Construction TFT Color LCD

Color filter, Glass substrate, Polarizers, Liquid crystal, Signal lines, Scan line, Thin film transistor, Transparent display electrode, Glass substrate, Back light

Stretched COP (Zeon, JSR)

Needs compensation film

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(a) Vinyl type

(b) Kevlar polymer

(c) polypeptide chain

Figure 1.9. Three different types of polymeric liquid crystals. (a) Vinyl type; (b) Kevlar polymer; (c) polypeptide chain.

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### 1.3 Some useful physical techniques

#### Differential Scanning Calorimetry (DSC)

Furnace, Gas vent, Gas in, Heat flux plate, T and  $\Delta T$  out

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Glassy/Semi-Crystalline      Semi-Crystalline      Liquid

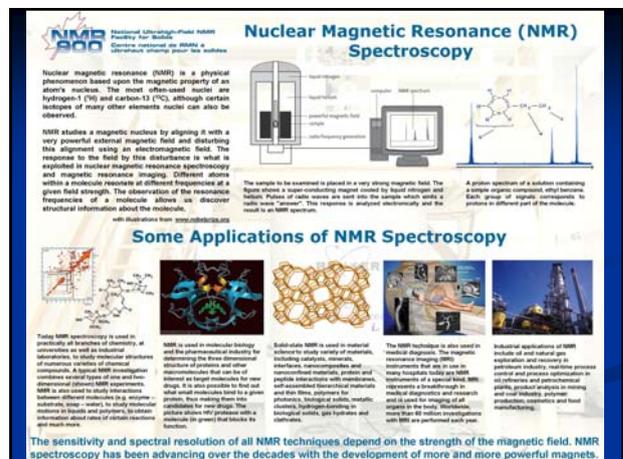
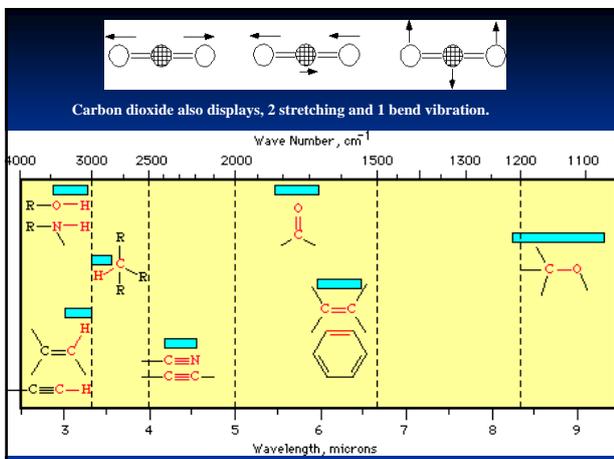
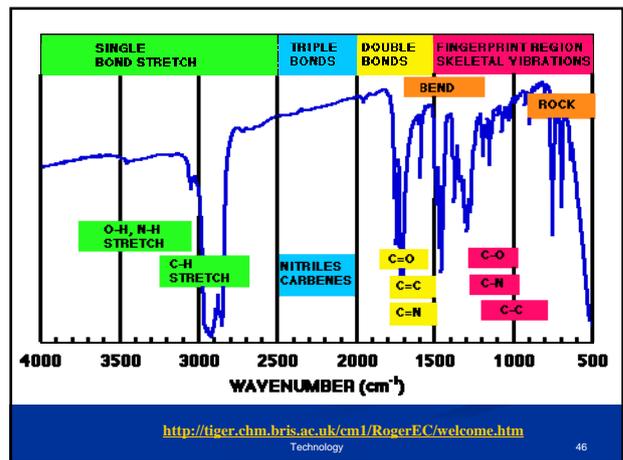
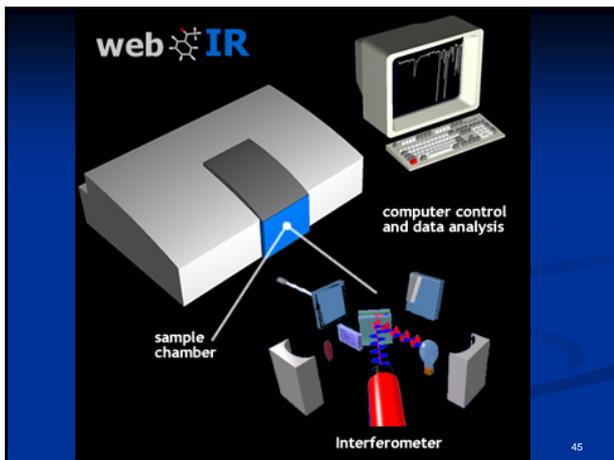
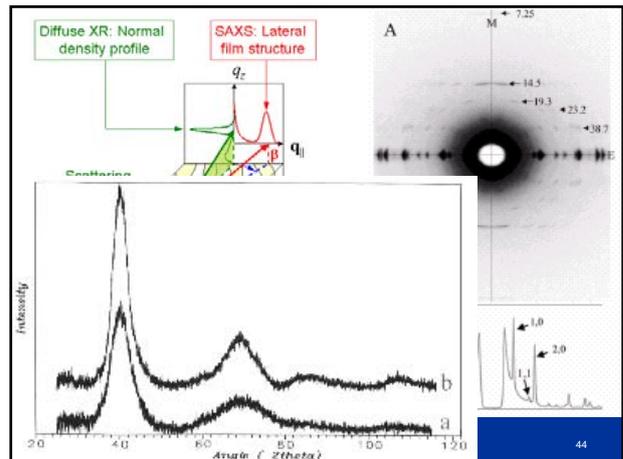
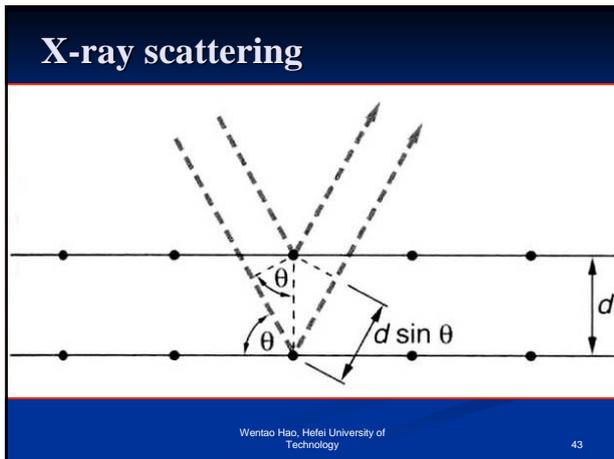
Endothermic

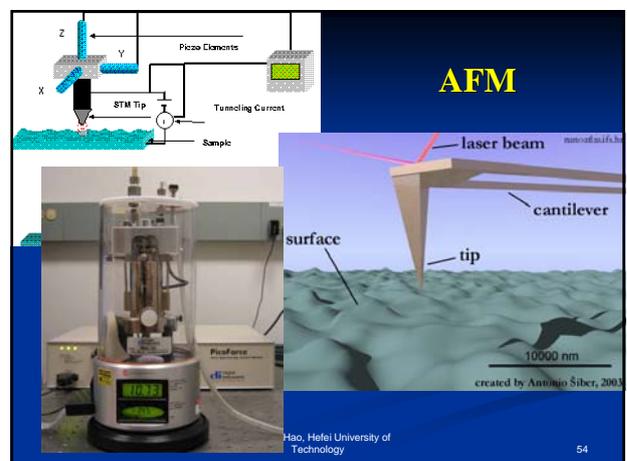
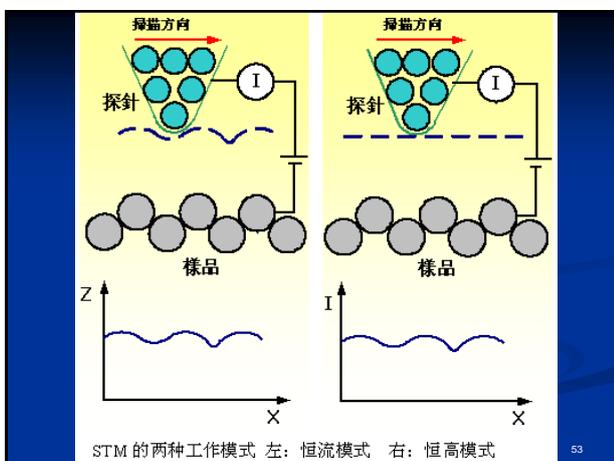
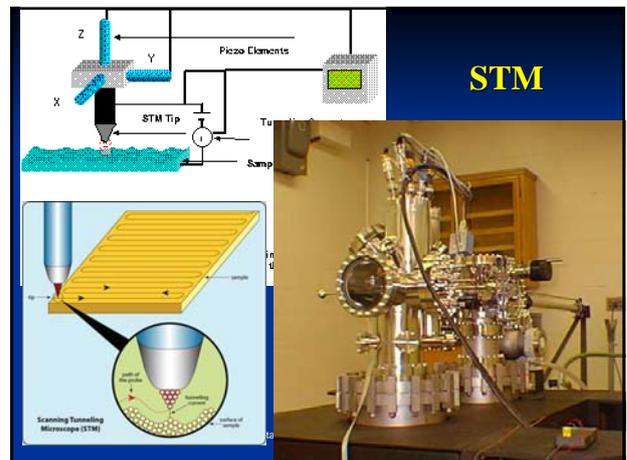
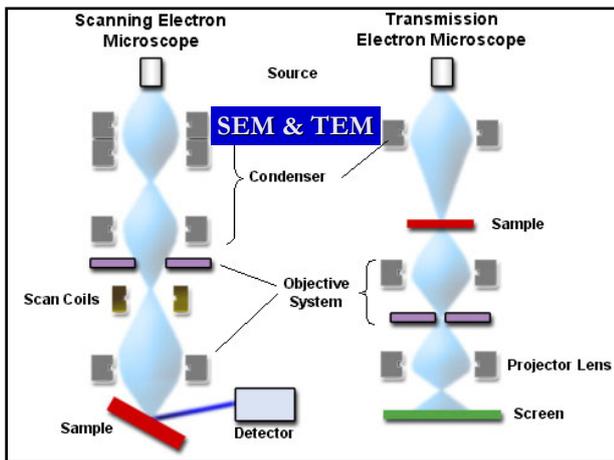
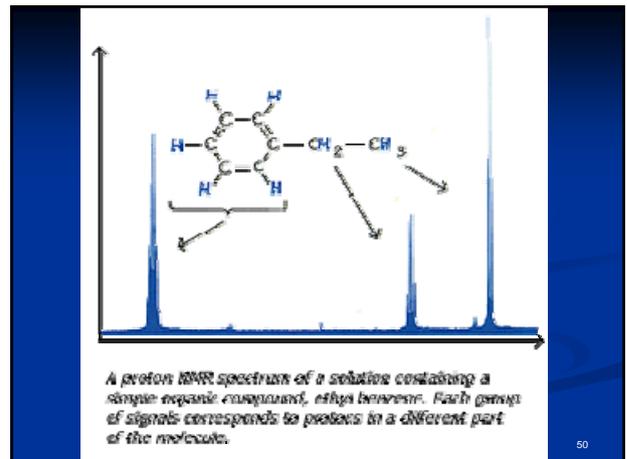
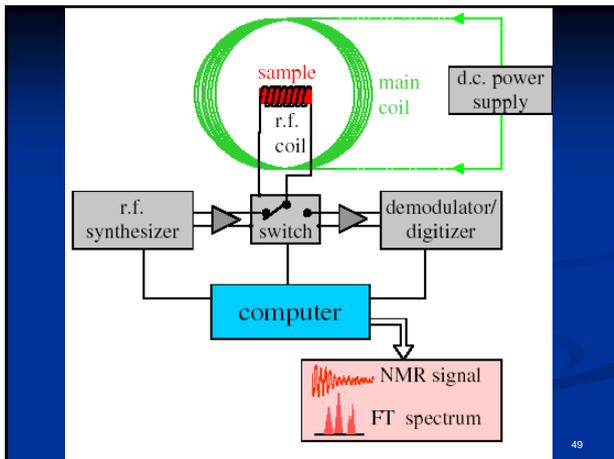
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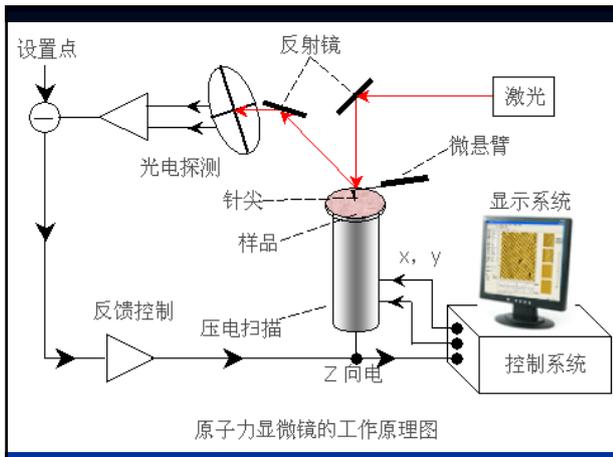
Hysteresis, Melting, Cold Crystallization, Glass Transition

Temperature (°K)

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# Time to Ask Questions

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## HOMWORK

- Why shall we learn the polymer structure?
- What are the four levels of polymer structure?
- What is the short range structure?
- What is “configuration” of polymer?
- Read some relative books or literatures and find the answer.

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