Lian Yu lab projects (space for 1 or 2 students)

(1) Crystallization in polymorphic systems (NSF, Abbvie, Lilly)

(2) Ultra-stable molecular glasses and amorphous drugs (NSF, Gates Foundation, BMS)

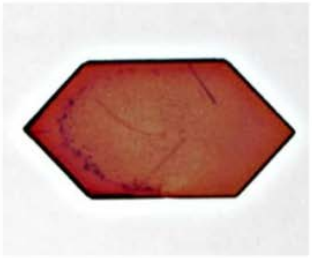
(3) Glasses with liquid-crystalline order (NSF)

Solid-state chemistry

Dosage form	Number/200 most prescribed drugs in US
Oral **solids** (tablets, capsules)	166 (**83 %**)
Injections	7
Subcutaneous	4
Ophthalmological	3, …

This is a powerful motivation for work in this area

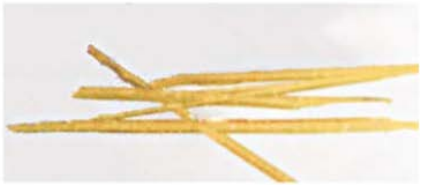
Molecules do amazing things in the solid state! ROY polymorphs

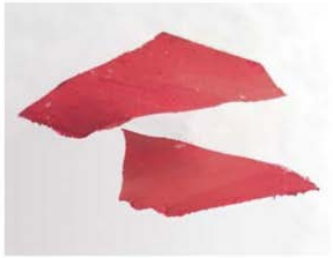


OP $P2_1/c$
mp 112.7 °C
θ = 46.1°

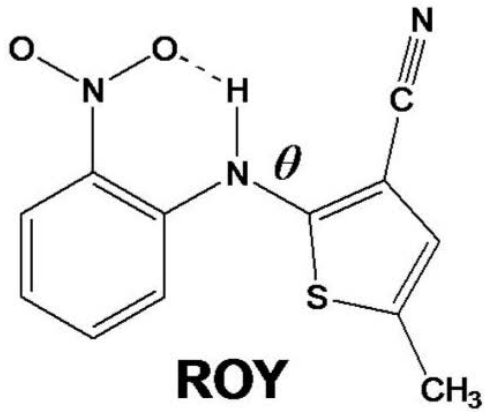
ON $P2_1/c$
mp 114.8 °C
θ = 52.6°

YN P-1
mp 99 °C
θ = 104.1°

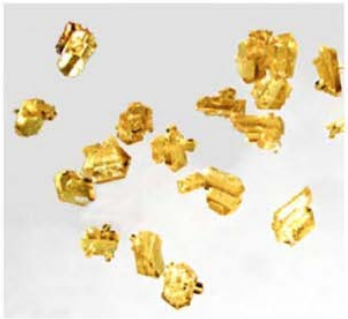




ORP Pbca
mp 97 °C
θ = 39.4°



ROY



Y $P2_1/c$
mp 109.8 °C
θ = 104.7°

R P-1
mp 106.2 °C
θ = 21.7°

YT04 $P2_1/c$
mp 107.0 °C
θ= 112.8°

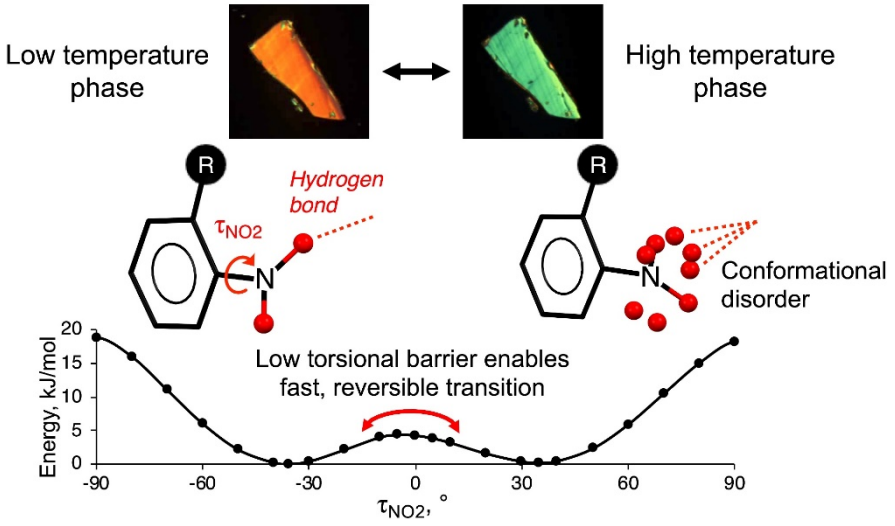
Polymorphs are important for all drugs, all solid materials

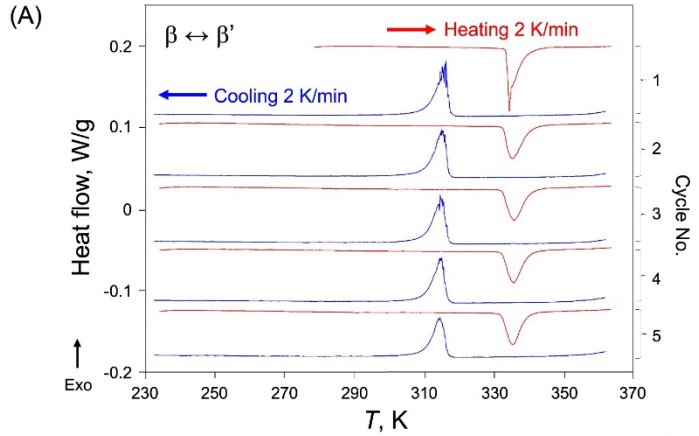
ROY was discovered 2 decades ago, still an international model

Most recent polymorph: Y19 (yellow, discovered in 2019)

NSF/Abbvie/Lilly project: Nucleation, materials design, and prediction of polymorphs

Reversible transitions for smart materials

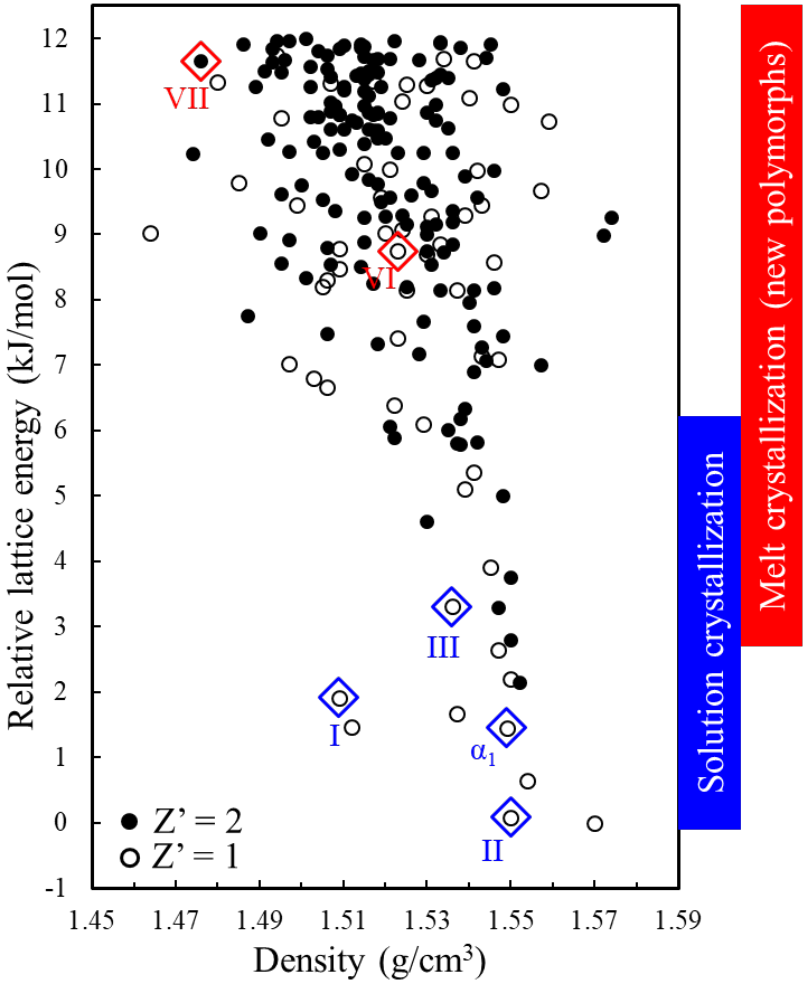




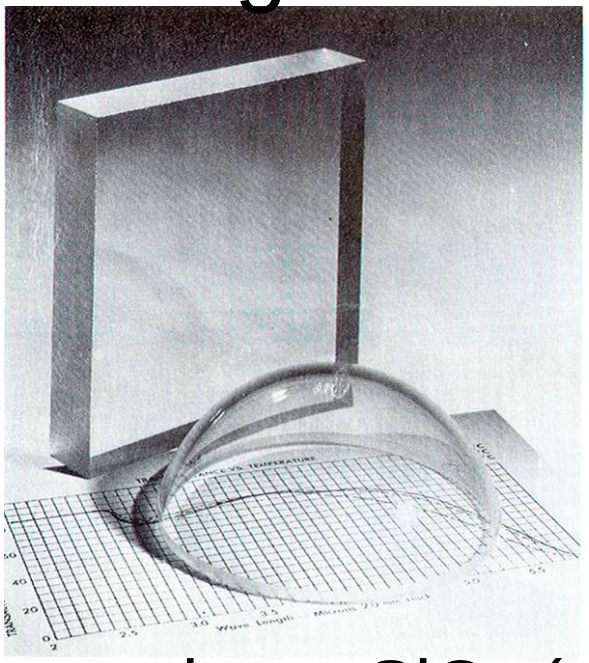
Yue Gui

Chemistry of Materials, in press

Computational chemistry to aid polymorph discovery



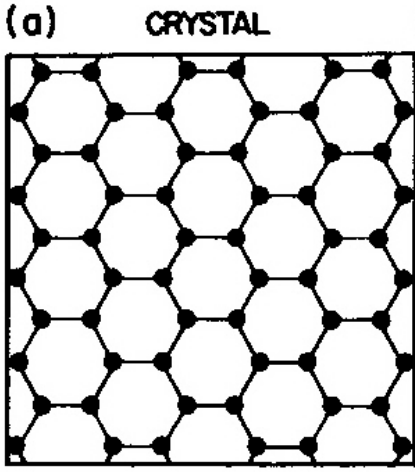
Solids can be crystals and glasses

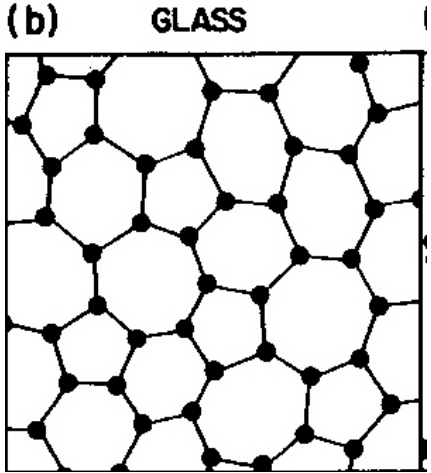


Crystalline SiO_2 (quartz)
Density 2.65 g/cm^3

Amorphous SiO_2 (glass)
Density 2.20 g/cm^3

The packing of atoms is regular and repeated in space





The packing has short-range order but lacks long-range order

Glasses are great materials!

Drug delivery
Amorphous drugs more soluble than crystals

AIDS drug Kaletra

Food

Bio-preservation

In sugar glasses

In amber

OLED

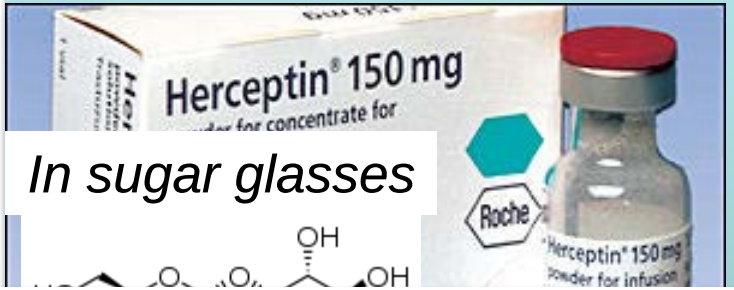
Glasses are great materials!

Drug delivery

Amorphous drugs more soluble than crystals

AIDS drug Kaletra

Bio-preservation



In sugar glasses

But must be stable against crystallization!

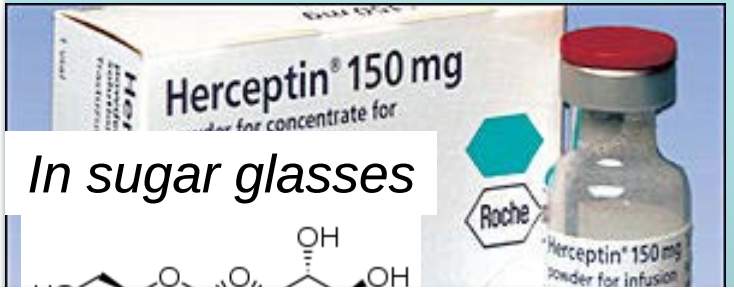
OLED

Glasses are great materials!

Drug delivery
Amorphous drugs more soluble than crystals

AIDS drug Kaletra

Bio-preservation

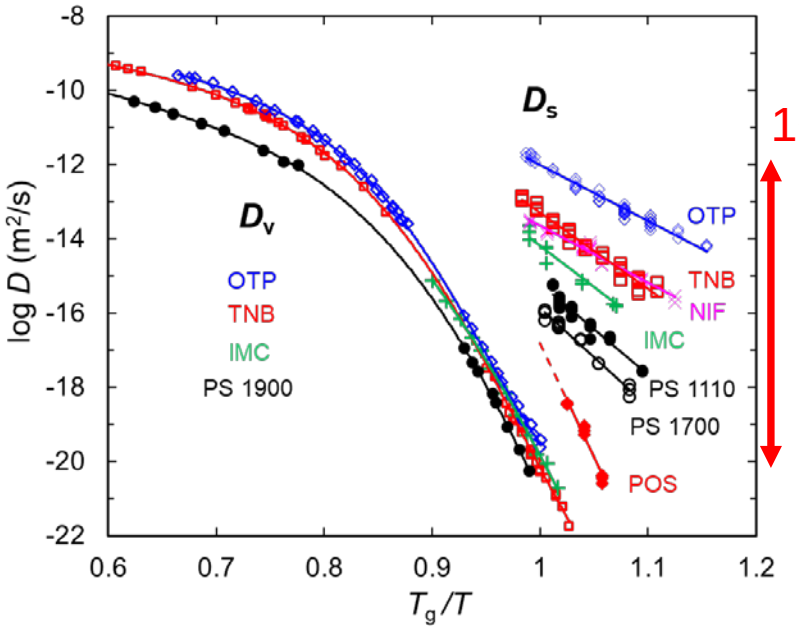


In sugar glasses

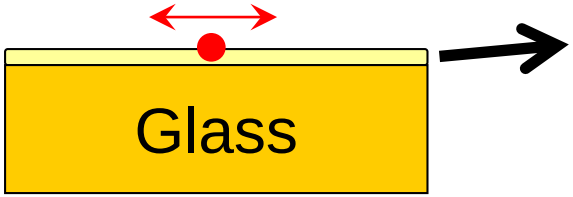
Should have tunable structures (as in the case of polymorphs)!

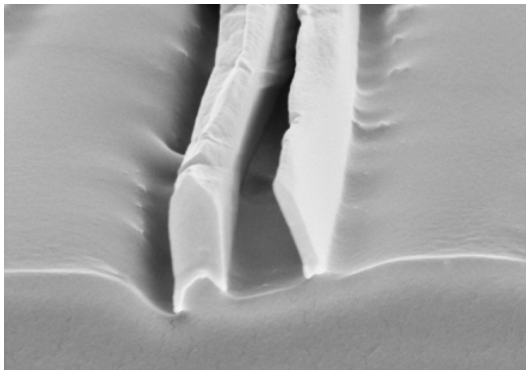
OLED

NSF project: Surface is the source of instability



10^8 x



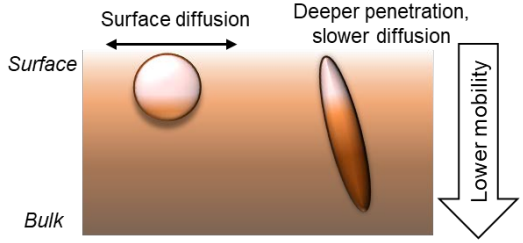


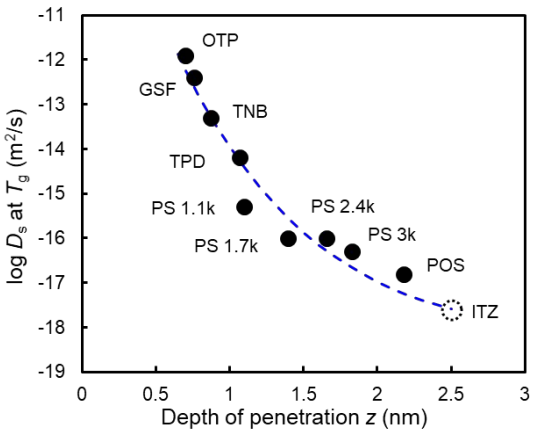
Fast surface crystallization

Penetration depth controls surface diffusion

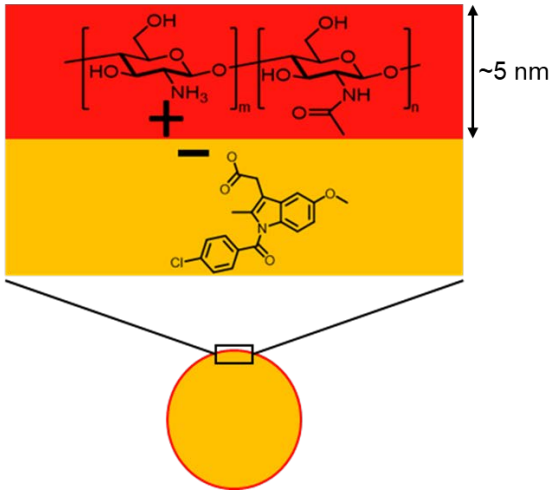
Yuhui Li

Soft Matter, 2020

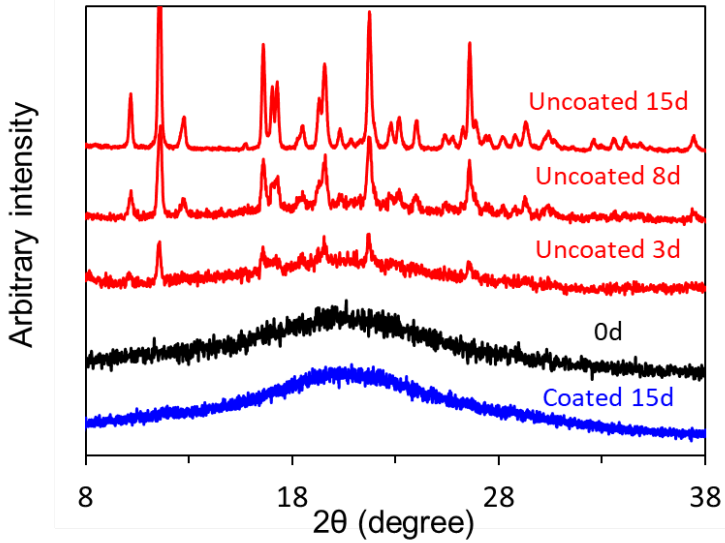




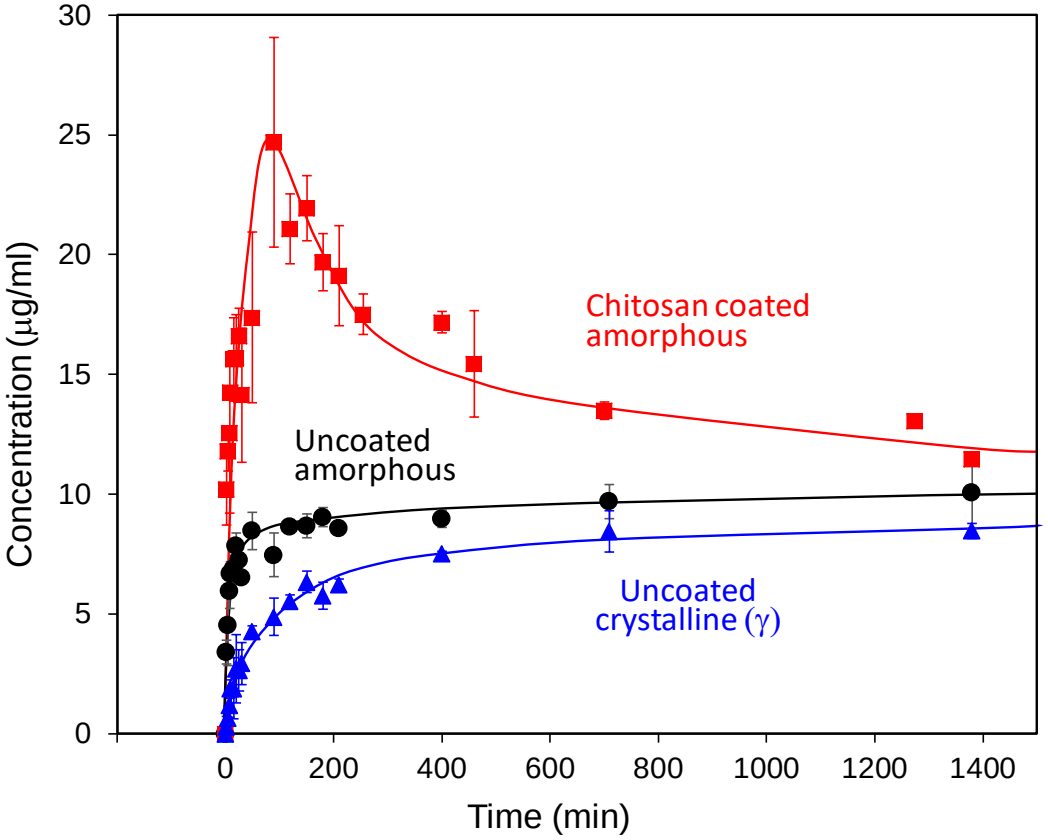
Gates Foundation project: Polymer coating to inhibit surface crystallization, enhance dissolution



Improved stability



Improved dissolution rate



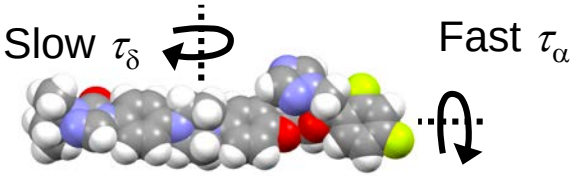
We are applying this strategy to develop drugs for global health

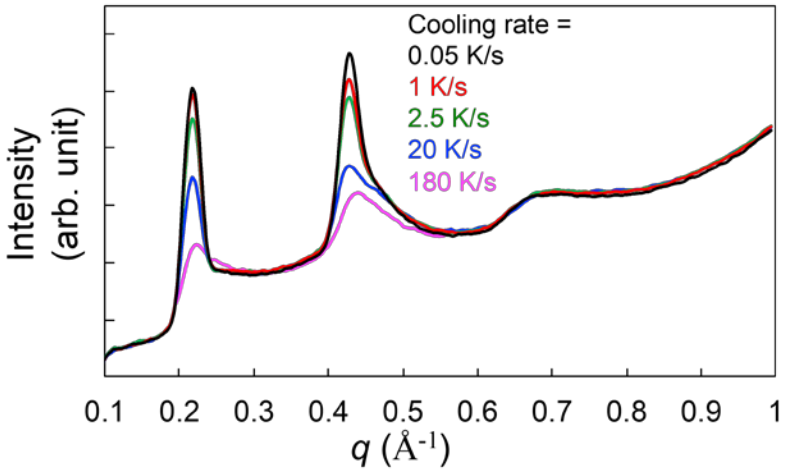
Li, Y.; Yu, J.; Hu, S.; Chen, Z.; Sacchetti, M.; Sun, C. C.; Yu, L. *Mol. Pharm*. **2019**, *16*, 1305

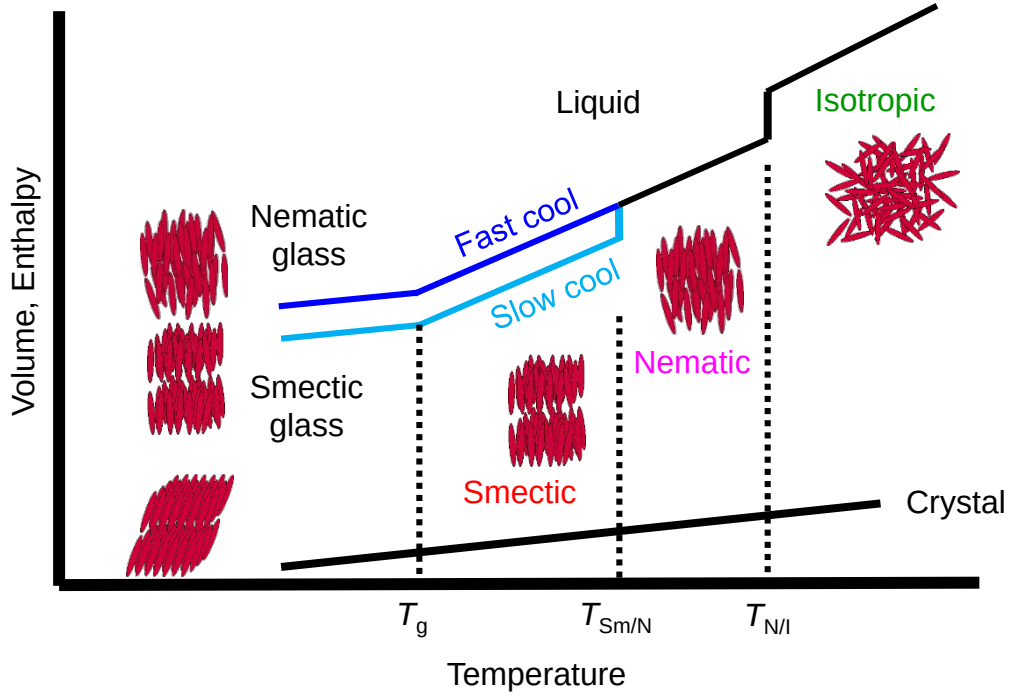
NSF project: Organic glasses with liquid-crystalline order

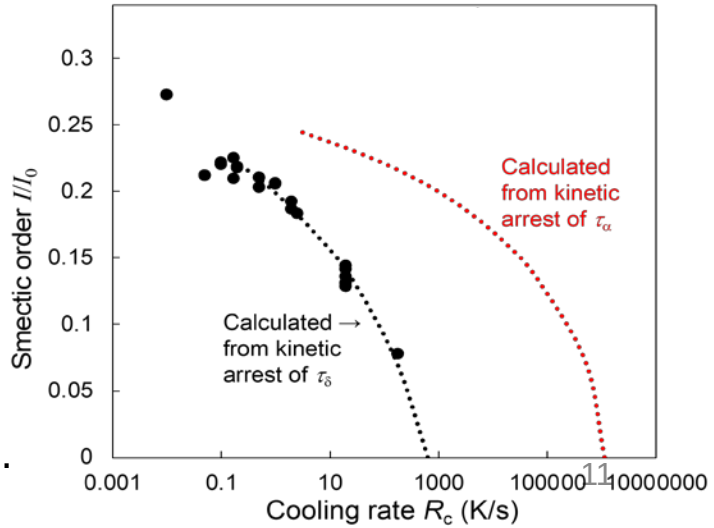
Zhenxuan Chen

- Ordinary glasses are “structure-less”
- We introduce LC order into glasses
- LC order is controlled by the arrest of the end-over-end rotation
- Useful for electronics and drug delivery









R. Teerakapibal, …, L. Yu. *Phys. Rev. Lett*. **2018**, *120*, 055502.
Z. Chen, …, L. Yu. *Soft Matter*, **2020**, *16(8)*, 2025-2030.

What experiments you may do?

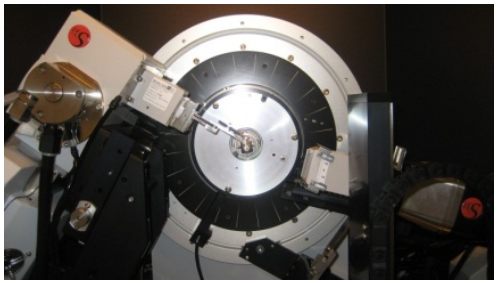
AFM

Calorimetry

Raman microscopy

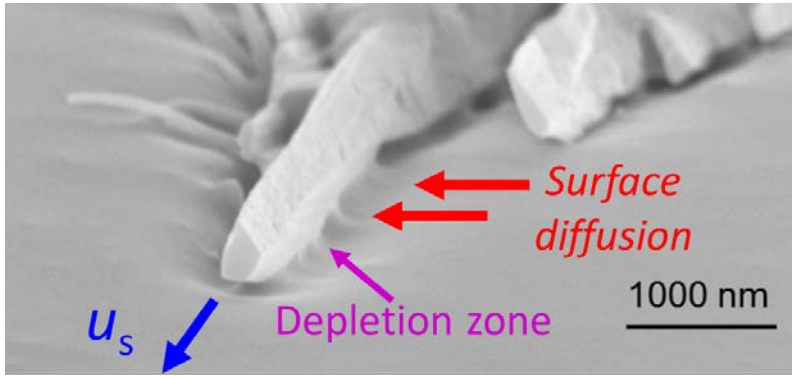
Light microscopy

X-ray diffraction



Argonne NATIONAL LABORATORY

SEM



Industrial connection

40 % funding from industry, 60 % from NSF

12 years in industry

Research covers fundamentals & applications

Student benefits

- Internship (usually Year 3)
- Job opportunities

Former students

Pfizer
Merck (4)
Genentech (2)
Amgen

AbbVie (3)
Aptuit
3 M
L'Oréal

Verseon
Mylan
XtalPi

Bristol Myers Squib (3)

City University of New York

Simmons College

China Pharmaceutical University

Lian Yu lab projects (space for 1 or 2 students)

(1) Crystallization in polymorphic systems (NSF, Abbvie, Lilly)

(2) Ultra-stable molecular glasses and amorphous drugs (NSF, Gates Foundation, BMS)

(3) Glasses with liquid-crystalline order (NSF)

Questions?

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Yuhui Li: yli873@wisc.edu

Yue Gui: ygui@wisc.edu

Group meeting 9 am, Tue

Pressure makes diamond

(wisdom from solid-state chemistry)