



# T24 Synthesis of Superconductor

## Collect:

- Agate mortar (clean with sponge after use)
- Label one zip-lock bag with student I.D. and name  
(To collect the synthesized superconductors)

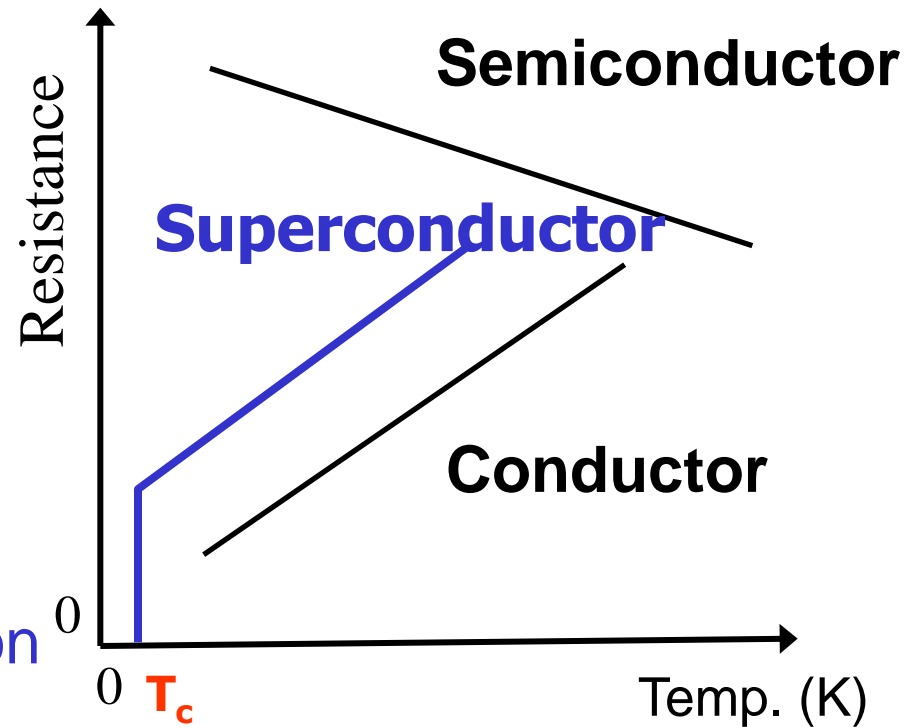
## Prepare:

- Plastic spatula x1
- Mask (self-prepared)



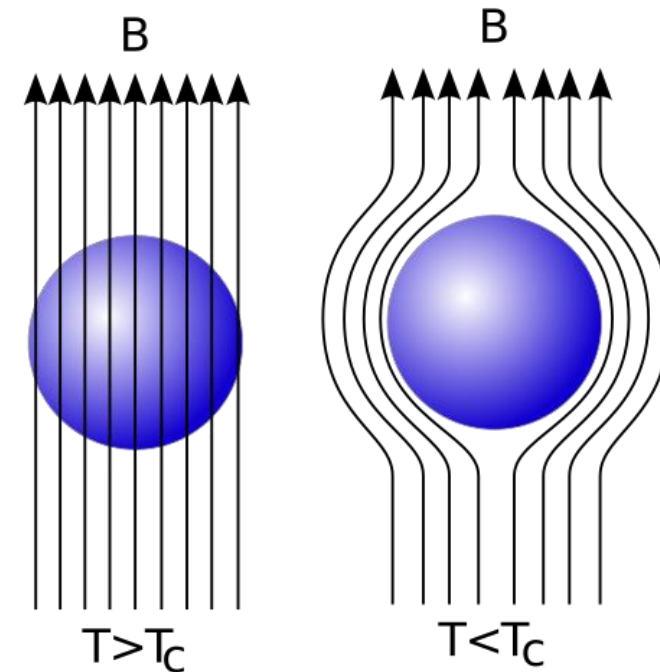
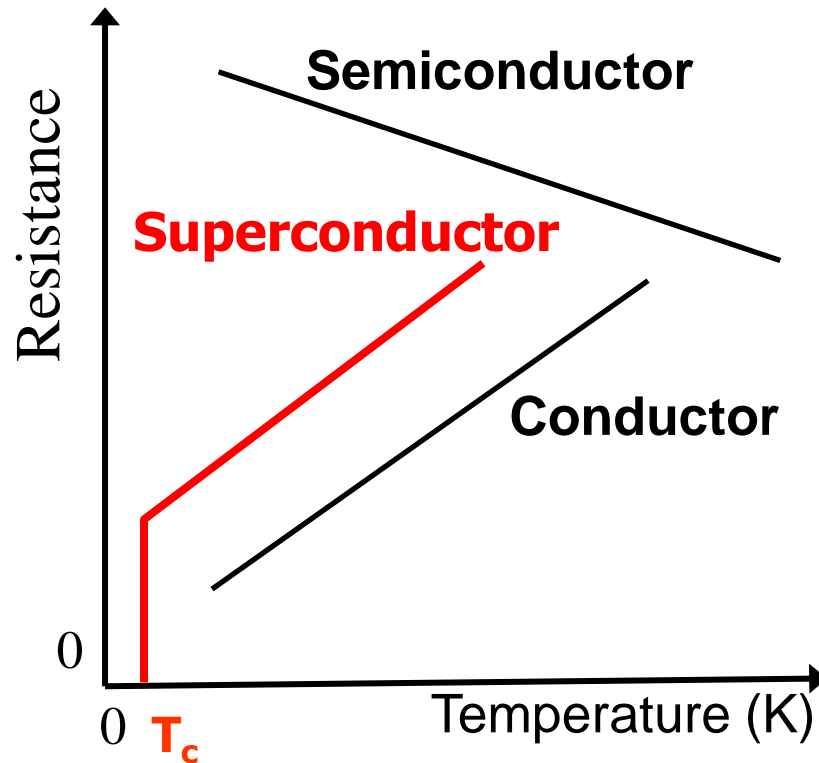
# Superconductors

- **Metal conductors**  
Conductivity decreases with increasing temperature
- **Semiconductors**  
Conductivity increases with increasing temperature
- **Superconductors**
  - Zero resistance at transition temperature





# Properties of Superconductors



(a) Temp. and resistance

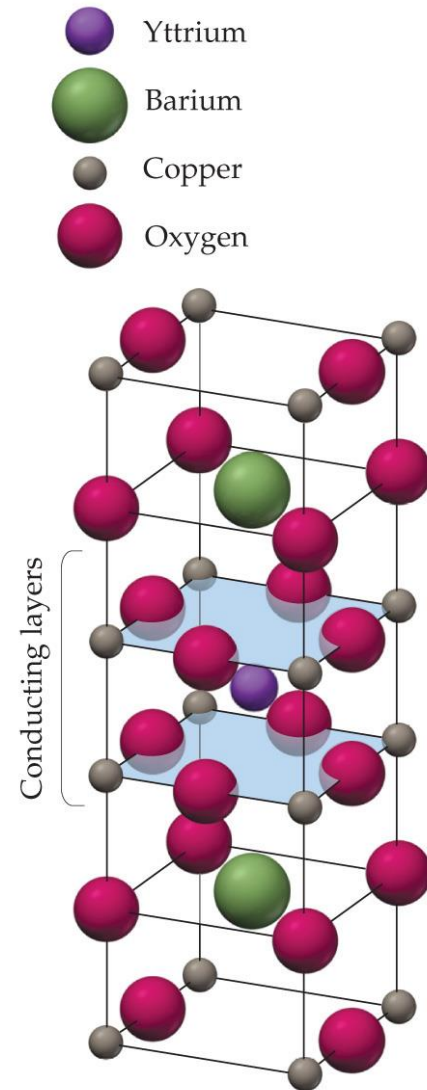
(b) The Meissner effect

- At superconducting transition temperature,  $T_c$ 
  - Zero resistance
  - Meissner effect



# Yttrium Barium Copper Oxide Superconductor

- Chemical formula:  
 $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$
- Crystalline structure
- $T_c$ : **95 K**  
(Boiling point of liquid nitrogen 77 K)
- Synthesis methods
  - **Solid-state reaction**
  - Sol-gel method
  - Co-precipitation





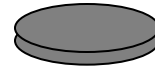
# Procedures of Solid-State Reaction

Yttrium oxide,  $Y_2O_3$   
Barium Carbonate,  $BaCO_3$   
Copper(II) Oxide,  $CuO$

Grind



Press  
 $1 \text{ ton/cm}^2$



$930^\circ\text{C}$ , in air



10 h



$YBa_2Cu_3O_{7-x}$   
superconductor

Atomic ratio

Y : Ba : Cu = 1 : 2 : 3



# Calculation of Formula

To synthesize 0.004 mol  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$   
(Y : Ba : Cu = 1 : 2 : 3 )

Obtain:

$$\text{Y}_2\text{O}_3 \quad 1/2 \times 0.004 \times 225.82 = 0.4516 \Rightarrow 0.45 \text{ g}$$

$$\text{BaCO}_3 \quad 2 \times 0.004 \times 197.31 = 1.5785 \Rightarrow 1.58 \text{ g}$$

$$\text{CuO} \quad 3 \times 0.004 \times 79.55 = 0.9546 \Rightarrow 0.95 \text{ g}$$

**\* The stoichiometric amount of starting materials you obtain is critical to the success of the experiment!**



# Grind and Mix the Reactants



Still contains white powder

- Use agate mortar (Costs NTD 9,000~15,000)
- Mix chemicals with plastic spatula first, then grind
- Grind until color appears to be gray and homogeneous, that may take about 10~15 min.
- Collect the ground powder in a piece of weighing paper



# Pressing— Hydraulic Press and Dies



Hydraulic press



Parts of dies



Hollow ring

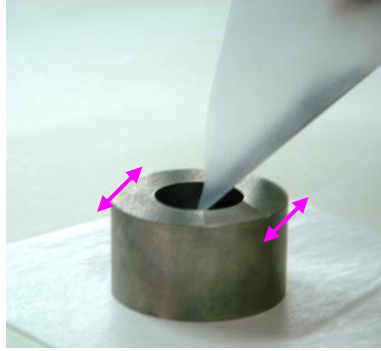




# Setup and Procedures of Pressing



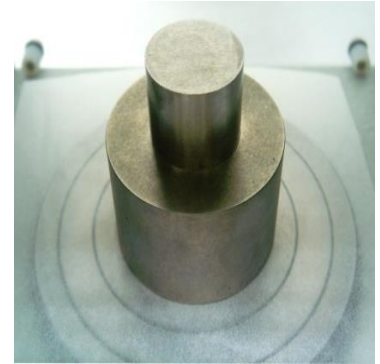
Place weighing paper underneath the die



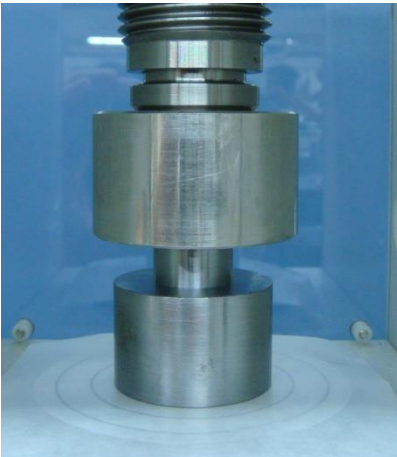
Transfer powder into die



Rotate the die left to right to even up powder



Place the dies on **center of hydraulic platform**



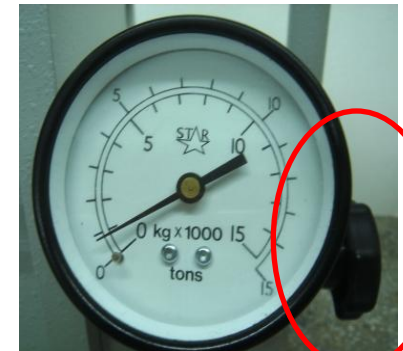
Fix the dies in position



Close the valve clockwise



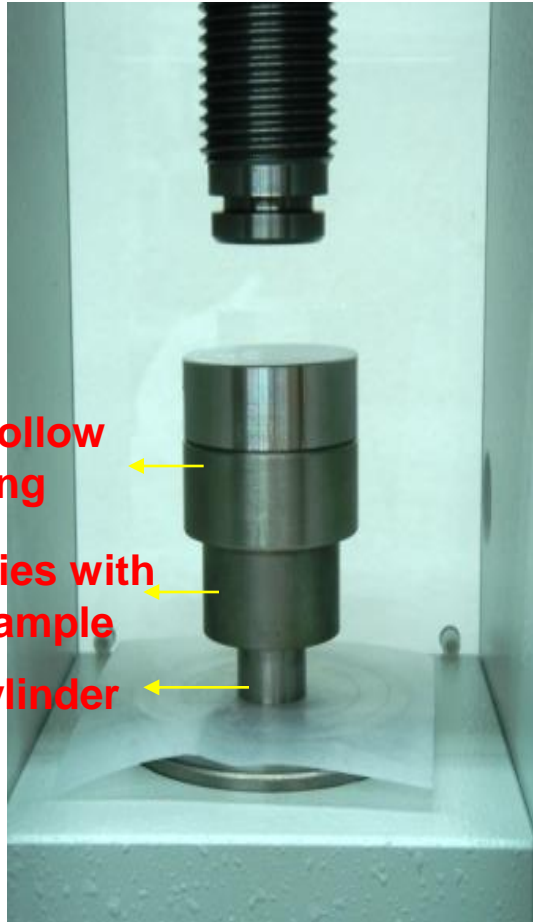
Apply the **pressure to 1 ton/cm<sup>2</sup> for 1 min.**



Release the valve **counter-clockwise**



# Setup and Procedures of Obtaining Pellet



Hollow ring

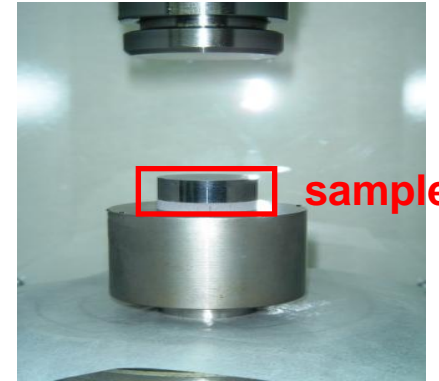
Dies with sample

Cylinder

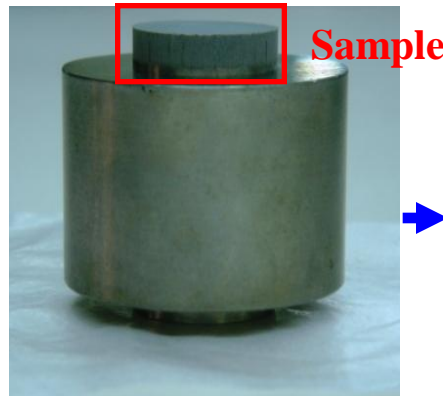
- Place the dies **in center of platform upside down**
- Setup the hollow ring and leveling surface



- Close the valve clockwise
- Pull leverage to surface the superconductor pellet



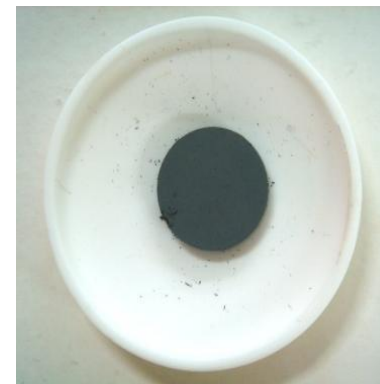
- Release the valve
- Take out the hollow ring



Resulting sample pellet



Place pellet on to an alumina plate with plastic tweezers carefully





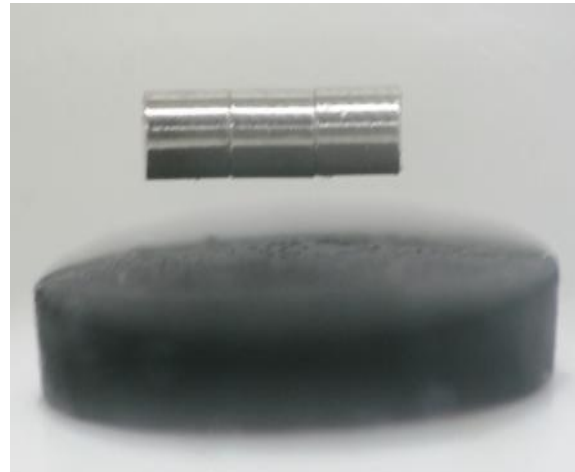
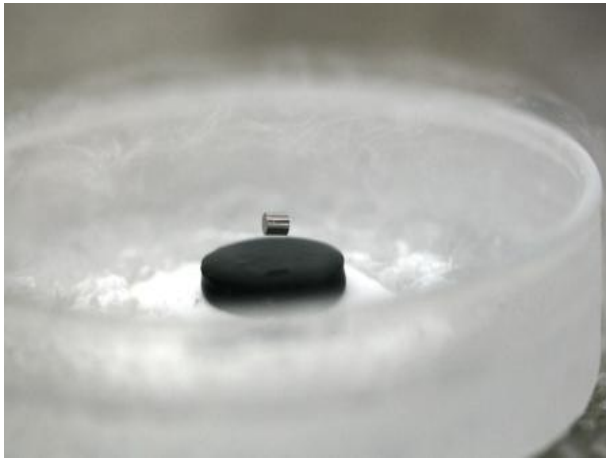
# Sintering at 930 °C



- The box furnace can hold  $4 \times 4 = 16$  samples
- Alumina plate cannot be labeled, record the position in furnace instead.
- Sinter the samples at 930 °C for 10 h. by raising and lowering the temperature at a rate of 5 °C/min.



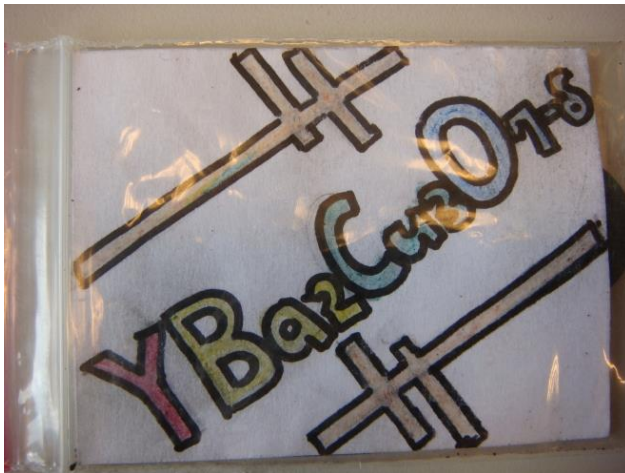
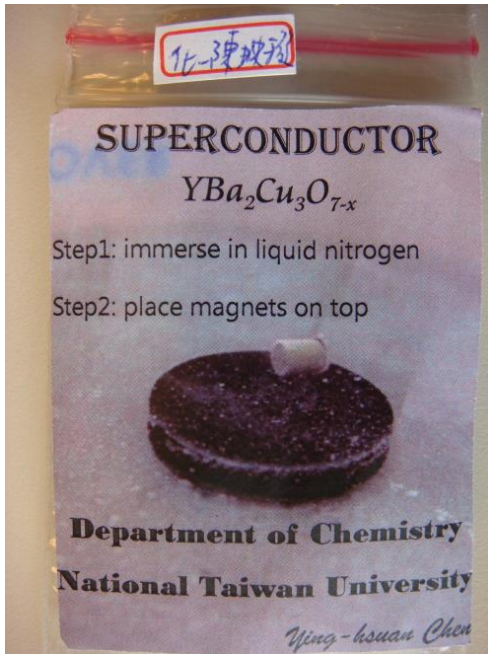
# Examine the Meissner Effect — Levitation of Magnets



- Place superconductor in petri dish
- Pour in liquid nitrogen and immerse the superconductor
- Place magnetic bars on superconductor pellet with plastic tweezers, compare levitation height and amount of magnetic bars
- Notice that the magnetic bars are small and easily lost
- Dry and warm the superconductor with a hair dryer to room temp.



# Design Your Superconductors as a Souvenir





# Notice

- The dies should be placed in center of platform to prevent uneven application of pressure when pressing
- Pressure should be kept at 1 ton/cm<sup>2</sup> for 1 min.
- Clean up the dies thoroughly after each use to avoid the powders pile up in dies and cause it to get stuck
- Avoid direct contact with liquid nitrogen which may cause frostbite