



**Laboratory of Magnetic Materials
National Chung Cheng University**

磁性材料實驗室簡介

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實驗室研究領域

- 硬磁

稀土永磁-複合奈米晶R-Fe-B、R-Co薄帶 (R: Rare Earth)

-異向性NdFeB燒結磁石強化、熱變形NdFeB磁石

-3D列印技術研製NdFeB膠磁

不含稀土之永磁-奈米晶Co-Zr及Co-Hf基薄帶

-硬磁燒結鐵氧體

- 軟磁

-高頻用薄膜材料

-自旋電子元件

- 磁致伸縮

- $\text{Fe}_{87}\text{Ga}_{13}$ -R、 $\text{Fe}_{100-x}\text{Al}_x$ -R、 $\text{Fe}_{80}\text{Al}_{20-y}\text{Ga}_y$ -Tb合金之機械性質研究

- 多鐵

- BiFeO_3 多晶薄膜纖構之控制與多鐵性質之研究

-鐵(壓)電/磁致伸縮奈米複合薄膜之多鐵性質及磁電效應之研究

實驗室研究設備

樣品製備

1. 電弧融煉 (Arc-melting)



2. 感應融煉系統



3. 熔融旋淬系統



4. 真空快速升溫退火爐



5. 真空熱壓機



6. 3D列印機



7. 高真空濺鍍機 (Sputter)

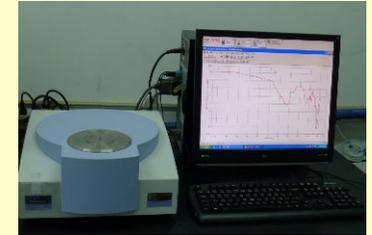
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分析設備

1. 結構分析鑑定—XRD



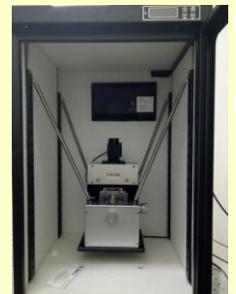
2. 熱分析—TMA、DTA、DSC



3. 磁性量測—VSM、BH-tracer

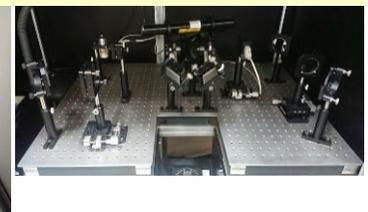


4. 電性量測-四點探針、LCR儀、P-E曲線儀

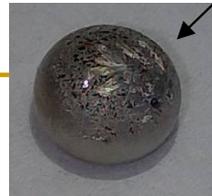


5. 表面形貌分析—AFM、MFM

6. 磁-機械性質分析-磁致伸縮、奈米壓痕、薄膜曲率儀



Arc Melting Furnace



Ingot alloys
Mass: 1-10 g

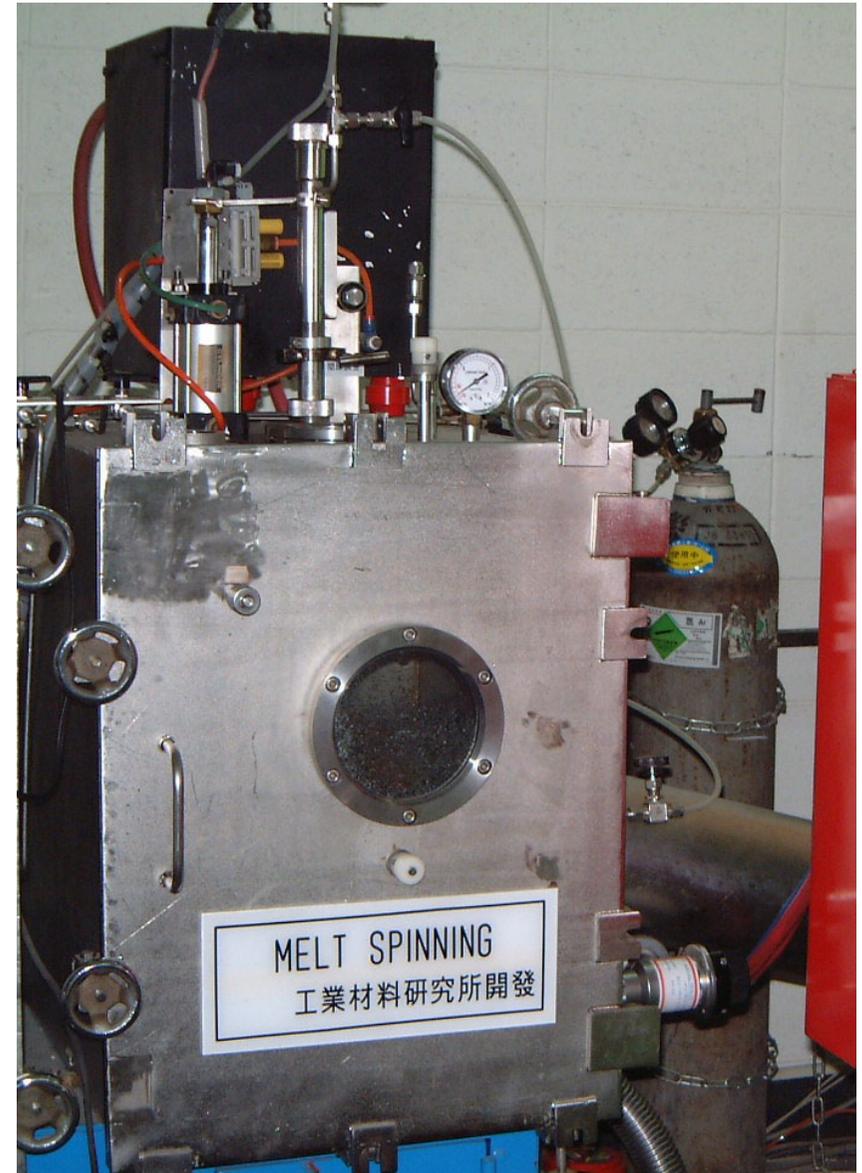
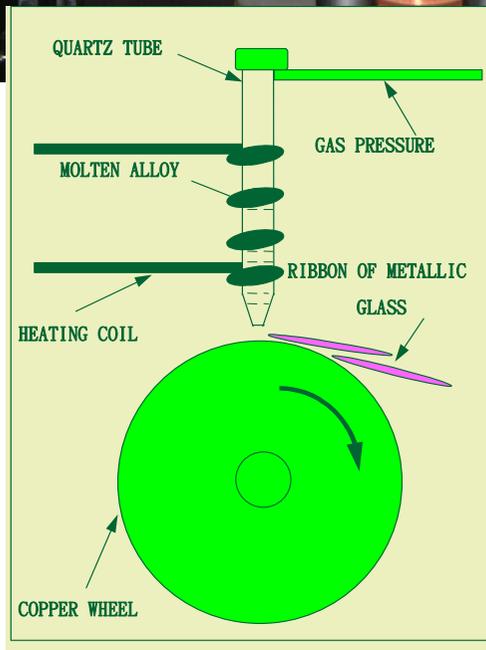
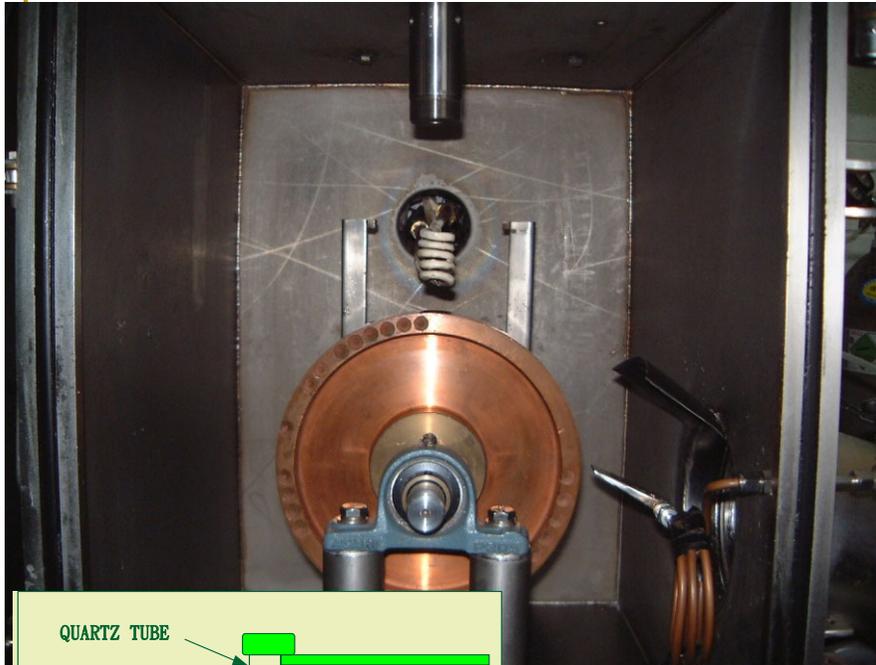
Vacuum Induction Furnace



Casting alloy

Mass: 100-500 g

Melt spinner



- $V_{\text{max.}} \sim 40 \text{ m/s}$
- $P < 10 \text{ mtorr}$

Nanocrystalline or amorphous ribbon

Vacuum Hot Press



- Max. hot pressed force ~ 10 Tons.
- $T \sim RT-1000\text{ }^{\circ}\text{C}$.
- The base pressure better than 10 mtorr.

RF/DC Sputtering System



HV-Sputtering system:
($P < 10^{-5}$ torr)



UHV-Sputtering system (8-gun):
preparation of multilayer films
($P < 10^{-8}$ torr)

Various Furnaces



T=RT-1200 °C

($P < 10^{-5}$ torr), T=RT-1200 °C

X-ray diffractometer



**Shimadzu
XRD-6000**

Differential Thermal Analyzer (DTA)

Perkin Elmer DTA-7

25-1100 °C

Reference: Al_2O_3 powder
Measure heat flow during heating



原理簡介：

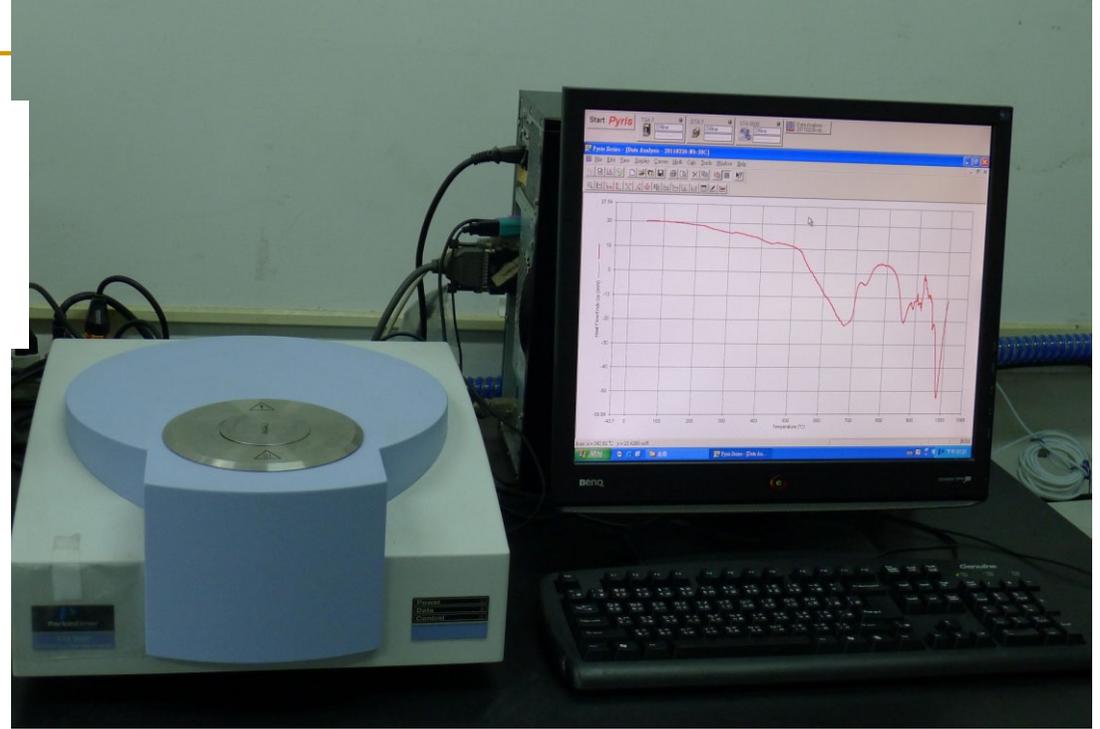
其利用晶體結晶時會有吸熱或放熱的原理，進而偵測其結晶化溫度。即把未結晶或微結晶之樣品置於DTA中，以一定的升溫速率下，在一定的溫度區間內(可由25-1100 °C)，在樣品與標準樣品氧化鋁粉做吸放熱比對，而測得樣品之結晶化溫度及判定其相所屬。

Differential Scanning Calorimeter (DSC)

Perkin Elmer STA-6000

25-1100 °C

Measure heat flow during heating and cooling.



原理簡介：

將樣品置於一個可透過程式控制升溫、降溫或恆溫的加熱爐中，通入氫氣做為環境氣體，當樣品與參考物質以線性的速度加熱或冷卻時，以適當的熱能使溫度維持相同，記錄所加入的熱量差異並對溫度作圖。當樣品發生蒸發、融熔、結晶等相變化時，可偵測焓變化或熱容量變化。而藉由能量隨溫度或時間變化情形，即可判定材料的反應熱、熔點、玻璃轉換溫度、結晶溫度及熱穩定性等。

Thermal Magnetic Analyzer (TMA)

Perkin Elmer TGA-7
RT-1000 °C

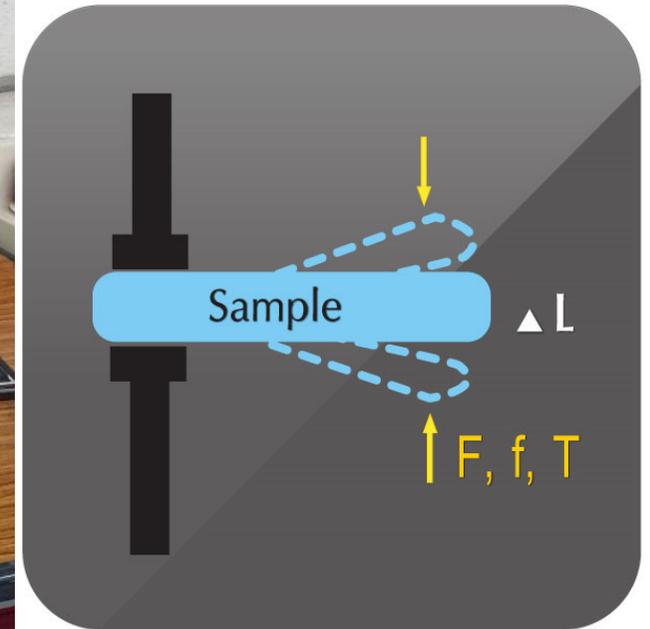
Measuring T_C of magnetic phase



原理簡介：

其利用磁性樣品的磁重會隨著溫度的增加而有所變化，當溫度達其所含有磁性相之居禮溫度時，磁重會發生遽烈地變化。在磁重對溫度作圖中形成峰值，故可得知樣品之磁性相存在與否，及其**磁性相的居禮溫度**，進而**判定其磁性相所屬**。

Dynamic Mechanical Analyzer(DMA)



TA Instrument 2980series

Measure **Young's and shear modulus** at various temperature
(RT-1000 °C) (**Bulk**)

Flux meter



Vibrating Sample Magnetometer (VSM)

DMS

- Virgin Curve
- Hysteresis Loop
- IRM and Virgin Curve
- DC Demagnetization (DCD)
- IRM and DCD
- Virgin Curve, IRM, DCD, Hyster
- Angular Remanence
- AC Remanence
- Time Dependence
- Temperature Scan

**for small sample
and films**

- **-150°C~300°C**
- **$H_{\max} = 12 \text{ kOe}$**



DC B-H Curve Tracer



for bulk magnets

$H_{\max} = 25 \text{ kOe}$
From RT to 200 °C

Magnetostriction meter



The strain gauge method – (**Bulk**)

($H_{\max} \sim 6 \text{ kOe}$)

Impulse excitation of vibration (IEV) method with the resonant frequency & damping analyzer (RFDA)



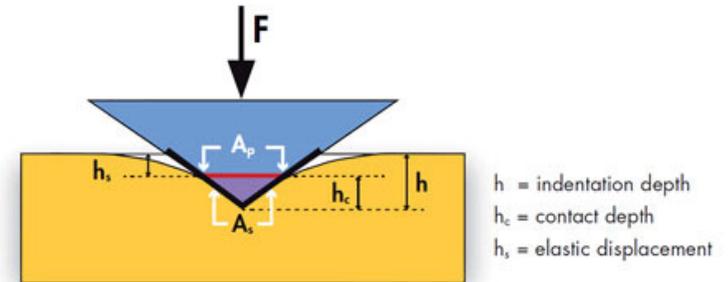
Young's and shear modulus and damping capacity at various H (0-2.5 kOe)

The samples with the dimension of 30 mm*12 mm*0.5 mm



Nanoindenter

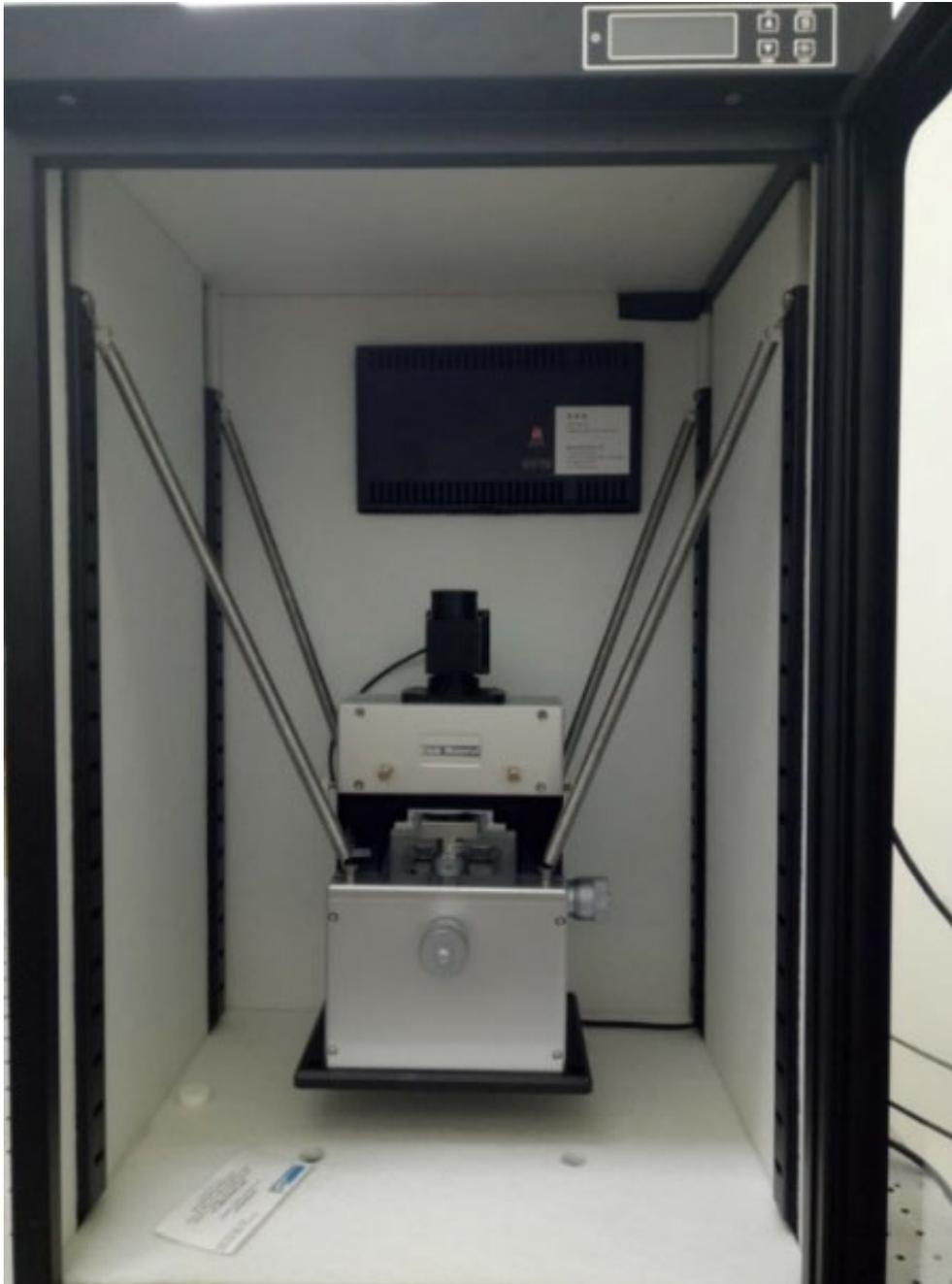
Measure Young's modulus and Hardness of **Films**



Bending Beam system

Measure stress of **Films**

AFM/MFM



**To observe surface morphology
and magnetic domain structure**



LCR meter (HP4284A)
(20 Hz- 1 MHz)



Network analyzer
(up to 3 GHz)

核心能力培養

- ✓ 專業能力培養－材料製備、材料分析及物理機制探討
- ✓ 訓練專業表達能力－蒐集彙整閱讀資料、組織編排、
投影片製作及表達答辯能力
- ✓ 團隊合作精神－Team Work

