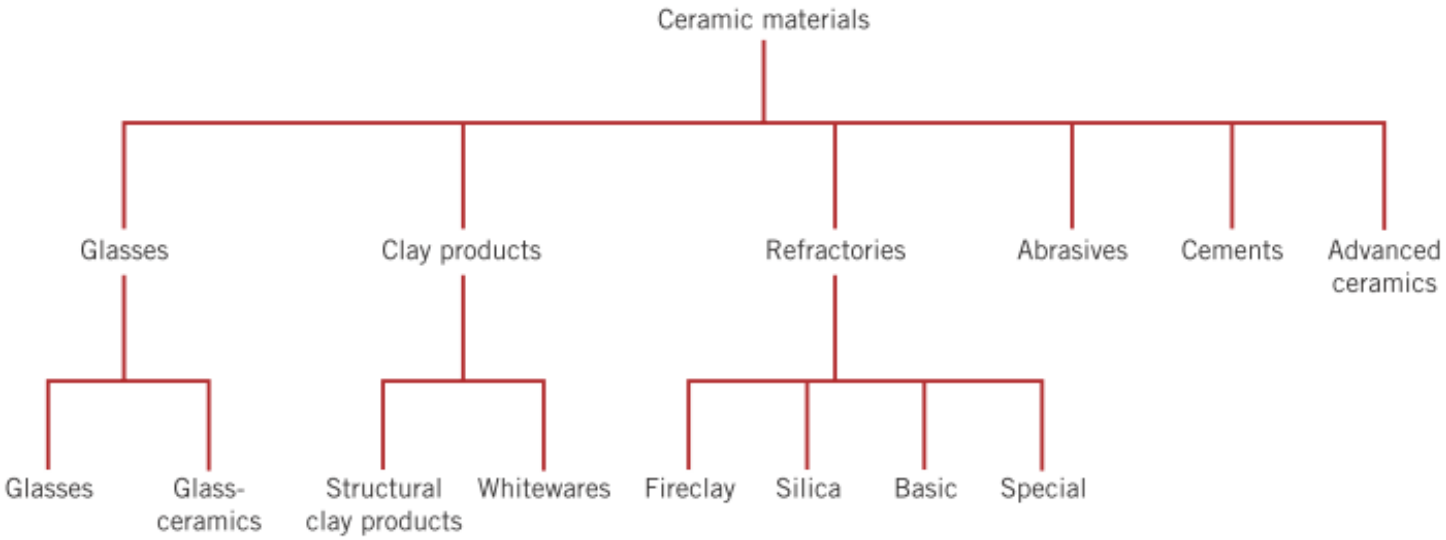
CH13 陶瓷應用與製程



Glasses&glass-ceramic

一些常用商用玻璃:

(soda - lime) *ition (wt%)*

Glass Type	*SiO_2*	*Na_2O*	*CaO*	*Al_2O_3*	*B_2O_3*	*Other*	*Characteristics and Applications*
Fused silica	>99.5	高熔點.低熱膨.抗熱振					High melting temperature, very low coefficient of expansion (thermally shock resistant)
96% Silica (Vycor™)	96				4		Thermally shock and chemically resistant—laboratory ware 器皿
Borosilicate (Pyrex™)	81	3.5		2.5	13		Thermally shock and chemically resistant—ovenware
Container (soda–lime)	74	16	5	1		4MgO	Low melting temperature, easily worked, also durable
Fiberglass	55		16	15	10	4MgO	Easily drawn into fibers—glass–resin composites
Optical flint	54	1				37PbO, $8K_2O$	High density and high index of refraction—optical lenses
Glass–ceramic (Pyroceram™)	43.5	14		30	5.5	$6.5TiO_2$, $0.5As_2O_3$	Easily fabricated; strong; resists thermal shock—ovenware

Crystallization※devitrification

→玻璃透過適當高溫熱處理

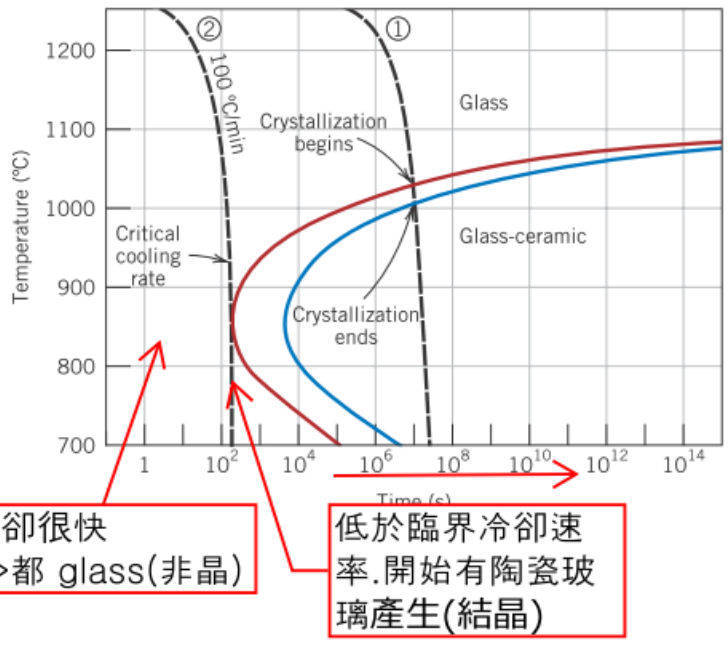
使非晶→結晶

產生 fine-grain 多晶→glass-ceramic

※成核劑:TiO_2

可以促進 crystallization!!

使曲線往就較短時間偏移



性質:
機械強度、低熱膨、抗熱振、高熱容、介電性質、生物相容
可製造成 trabsparent 或 opaque

※ Pyroceram™, Corningware™, Cercor™, and Vision™.

Clay product
大致上分成兩類
1.structural clay product→building bricks, tiles, and sewer pipes
2.whitewares→經高溫 firing 變白→clay、quartz、flux→ porcelain, pottery, tableware, china, and plumb-
ing fixtures (sanitary ware)

REFRACTORIES
Refractory ceramic-
性質就顧名思義，耐火
主要是應用在→以 brick(磚)的型式
典型應用→ furnace linings for metal refining, glass manufacturing, metallurgical heat treatment, and power generation
依據不同的成份有不同的表現

Refractory Type
Fireclay
High-alumina fireclay
Silica
Periclase
Periclase–chrome ore

Silica Refractories
高溫負載!
抵抗acid
slags(silica)害怕basic
slags(MgO.CaO)

Fireclay Refractories 25 and 45 wt% alumina.
提高氧化鋁能增加最大使用溫度
在應用上允許小量液體 強度並非主要考量

Table 13.2 Compositions of F

	Composition (wt%)						
Refractory Type	Al_2O_3	SiO_2	MgO	Cr_2O_3	Fe_2O_3	CaO	TiO_2
Fireclay	25–45	70–50	0–1		0–1	0–1	1–2
High-alumina fireclay	90–50	10–45	0–1		0–1	0–1	1–4
Silica	0.2	96.3	0.6			2.2	
Periclase	1.0	3.0	90.0	0.3	3.0	2.5	
Periclase–chrome ore	9.0	5.0	73.0	8.2	2.0	2.2	

Source: From W. D. Kingery, H. K. Bowen, and D. R. Uhlmann, *Introduction to Ceramics,* 2nd edition 1976 by John Wiley & Sons, New York. Reprinted by permission of John Wiley & Sons, Inc.

Basic Refractories
Periclase.MgO
抵抗鹼性溶渣
害怕酸性溶渣

共晶成份:7.7wt%氧化鋁
所以氧化鋁會降低液相線溫度
-->要維持很小量!

※特殊耐火物

高純度氧化物材料、很小的孔隙度、

silica, magnesia, beryllia (BeO), zirconia (ZrO_2), and mullite ($3Al_2O_3$–$2SiO_2$). Others include carbide compounds, in addition to carbon and graphite. Silicon carbide

(SiC)

碳和石墨很耐火，但他的限制是高溫使用時容易氧化

Abrasive ceramics

Diamonds, both natural and synthetic, are utilized as abrasives; however, they are relatively expensive. The more common ceramic abrasives include silicon carbide, tungsten carbide (WC), aluminum oxide (or corundum), and silica sand.

CEMENTS

cement, plaster of paris, and lime

cement 的角色→類似 glassy bonding phase，最大的差別是，cementitious 發生在室溫

Portland 生產最多!

製程:

以適當比例研磨混合 clay 和 lime-bearing minerals，在 rotary kiln 加熱

→calcination

→產生“clinker” product，然後再添加 gypsum(石膏)，延緩 setting 過程

又稱 hydraulic cement→硬度是來自水合作用

$$2CaO–SiO_2 + xH_2O = 2CaO–SiO_2–xH_2O$$

※lime→nonhydraulic→硬化反應為非水化合物(CO_2)

先進陶瓷

1.MEMS

2.Optical Fibers→high-purity silica

3. Ceramic Ball Bearings→ silicon nitride(Si_3N_4) ball

Steel races VS Si_3N_4

拉伸強度較高	密度較低 較硬(低磨耗) 摩擦係數小→產生熱較少 電絕緣體

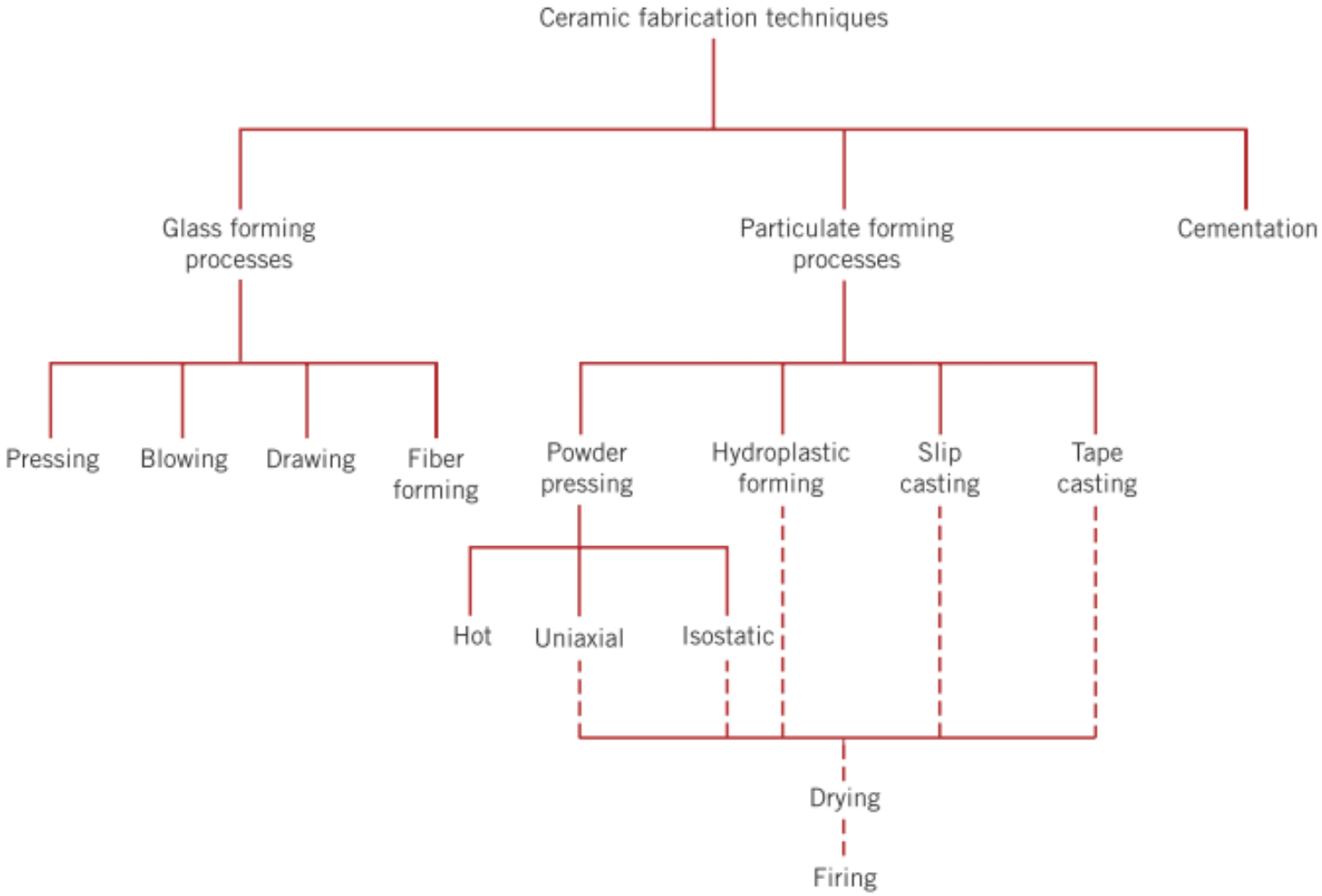
※combination of ceramic balls and steel races is termed a hybrid bearing

4.壓電陶瓷→機械應變導致不尋常的壓電性→electric polarization

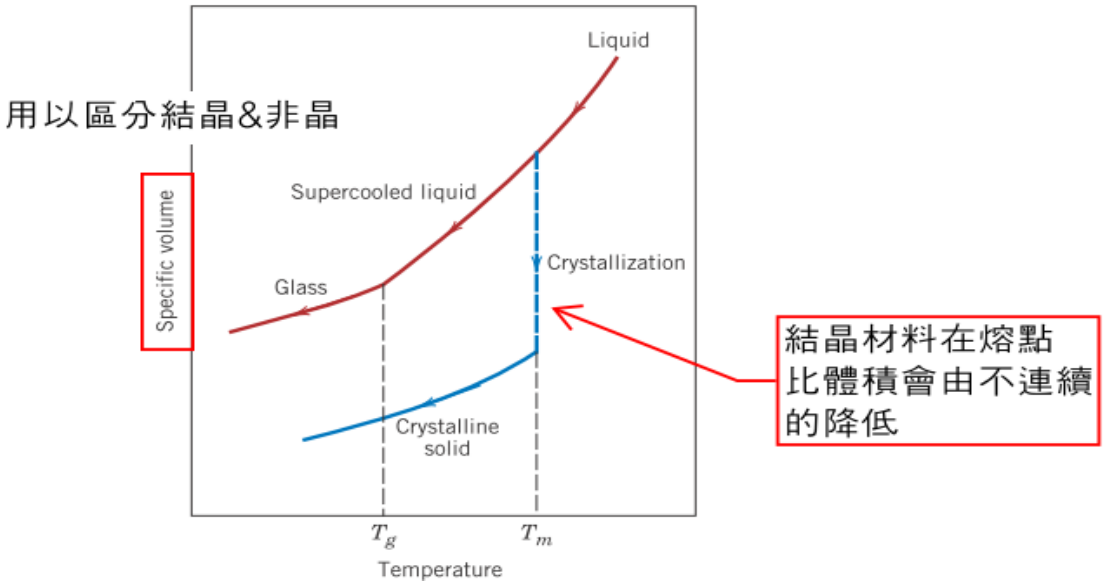
Commonly used piezoelectric ceramics include barium titanate ($BaTiO_3$), lead titanate ($PbTiO_3$), lead zirconate–titanate (PZT) [$Pb(Zr,Ti)O_3$], and potassium niobate ($KNbO_3$).

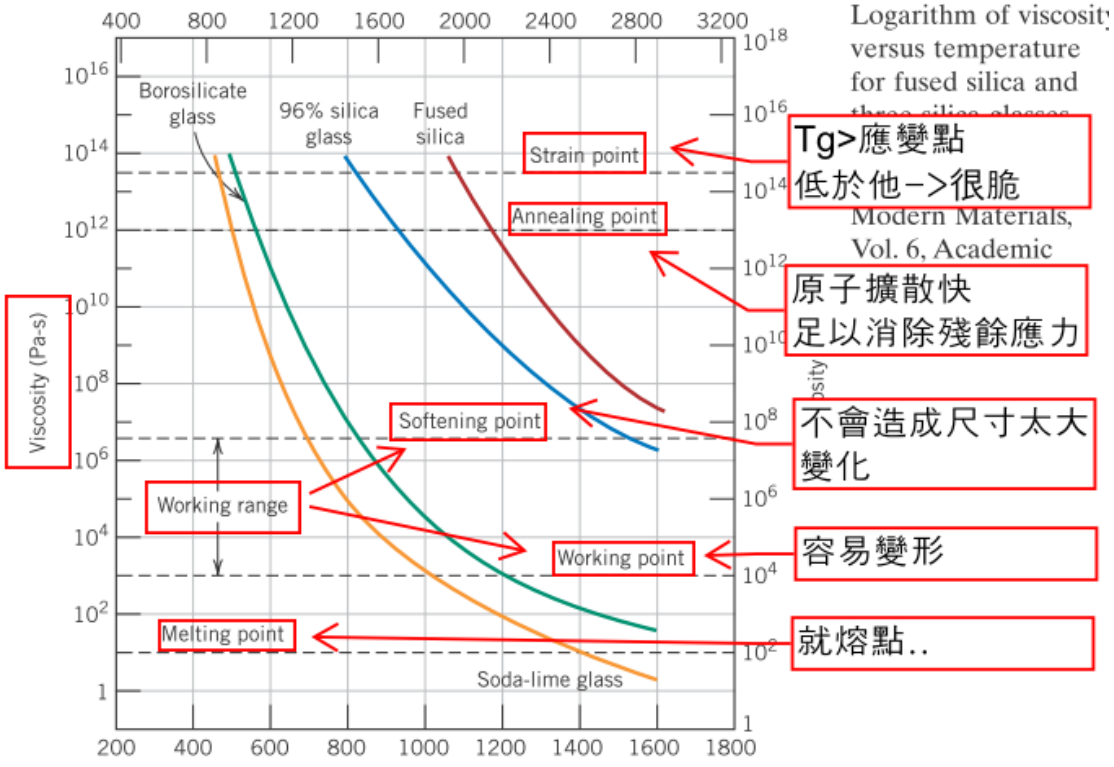
※聲納

陶瓷製程



玻璃性質



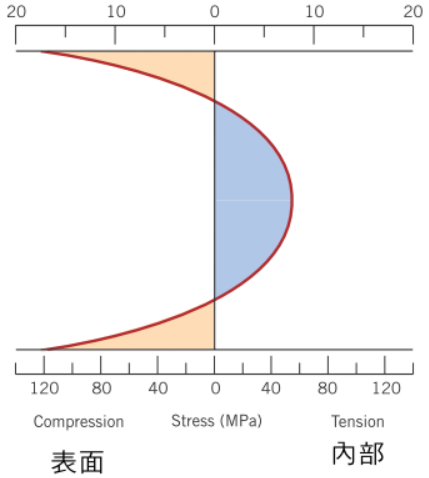


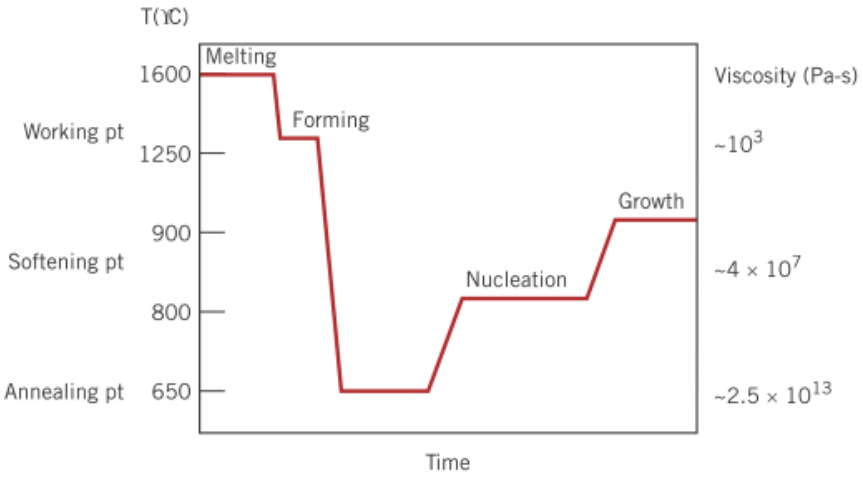
玻璃熱處理

退火→加熱至退火點，緩冷至室溫→消除熱應力、避免熱震

Chemical tempering→表面陽離子與其他較大陽離子互換

Tempering→刻意引入壓縮殘餘應力來強化(thermal tempering)→加熱到大於 T_g 小於軟化點的溫度，再空冷或油冷，因內外冷卻速率不同，產生殘於應力





Clay

特性

1.hydroplasticity→加水後具塑性!

2.由氧化鋁和矽石(SiO_2)組成

3.

Kaolinite clay $[Al_2(Si_2O_5)(OH)_4]$

水加入後，在層狀薄層之間形成薄膜於黏土周圍→塑性

When mixed with clay, a flux forms a glass that has a relatively low melting point. The feldspars are some of the more common fluxing agents; they are a group of aluminosilicate materials that contain K^+, Na^+, and Ca^{2+} ions.

製程與技術

Hdroplastic forming→extrusion(類似金屬的)

Slip casting

※若強度不足(孔洞.液體)

先乾燥 drying→產生 green→再焙燒 firing→孔隙度降低，密度增加→高溫時，會產生 vitrification

※vitrification 越高→越透光→變軟(非晶)

Powder pressing

Uniaxial、isostatic(hydrostatic)、hot pressing

其中對 Uniaxial、isostatic，pressing 之後要 firing，

會產生 the coalescence of the powder particles into a more dense 的現象→sintering

驅動力為全部顆粒表面的降低(表面能比晶界能還大)

※在熔點以下實施，部會出現液相

Tape casting→薄物件