MSE-326 – Ceramic and Colloidal Processing
Examples of ceramic pieces, grouped by forming methods, also raw powders and additives

Topic – see commented video – see Moodle week 8 or https://tube.switch.ch/videos/d9de69d2	
1. Natural Raw Materials - Powders	
2. Synthetic Raw Materials - Powders	
3. Dry Pressing - Uniaxial	
4. Dry Pressing - Isostatic	
5. Slip Casting	
6. Tape Casting	
7. Plastic Forming – Jiggering- Potters Wheel	
8. Plastic Forming - Extrusion	
9. Plastic forming – Injection Moulding	
10. Additive Manufacturing - Stereolithography	
11. Thin Films – Vapour Deposition	
12. Surfactants and Colloidal Dispersion	

1. Natural Raw Materials - Powders

- Kaolin – Feldspar – Quartz – the raw powders for the production of hard porcelain (Week 3 Slide 15)
- Exfoliated Vermiculite : 2:1 clay – swellable clay – exfoliated by rapid heating – water between the clay sheets creates high water vapour pressure which pushes sheets appart – used as packaging for dangerous chemicals (Week 3 Slides 16-17)
- Ball clay – an impure kaolin (aluminoslilicate) – used on soft porcelain, sanitary wear and earthenware – Week 3 Slide 15
- Talc (Magnesium silicate) – used with kaolin (70%) talc (30%) to make synthetic cordierite by extrusion for automobile catalyst support – week 3 – slide 12 & week 11 slide 36 – plastic forming - extrusion

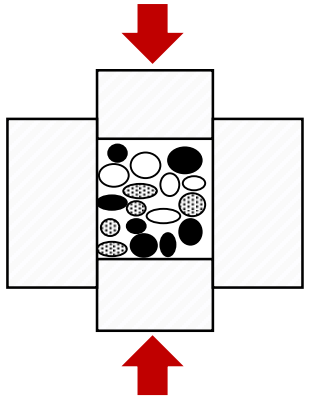
Ball clay

2. Synthetic Raw Materials - Powders

- Yellow powder - Strontium Aluminium Chromate, $Sr_8(Al_{12}O_{24})(CrO_4)_2$ ….week 4 slide 33 – formed by spray pyrolysis
- Amber Powder – Synthetic diamond – the yellowish coloration is from nitrogen impurities from synthesis method (high pressure sold state synthesis) – application polishing of sintered ceramics.
- SiC – silicon carbide – e.g. application abrasive paper – synthesized via the Acheson method – week 3 slides 41-42
- Gamma – alumina – nanosized powder – heavily agglomerated – week 4 slide 29
- Tetragonally stabilized ZrO_2 – yttrium doped (3% atomic) – TZ 3YB – lot no. 304196B

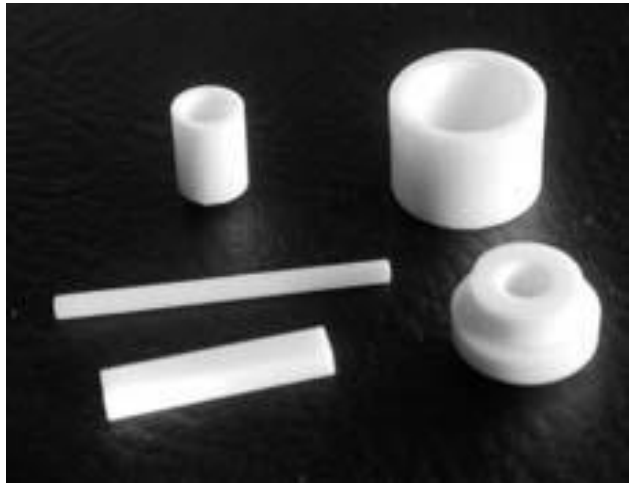
SiC

3. Dry Pressing - Uniaxial



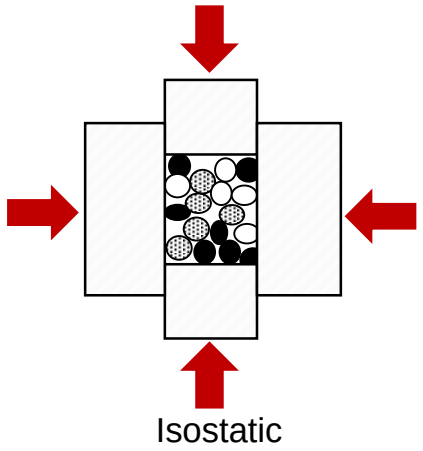
Uni-axial

- Ceramic Knife
- Video – https: //www.azom.com/materials-video-details.aspx? VidID = 386
- Powders are granulated to facilitate forming by dry pressing (automatic)
- Video -uniaxial dry pressing 1.5 mins, Morgan Process Animations - Die Dry https://www.youtube.com/watch?v=WuxRkt_ics0
- Small ring – valve seat for ball valve – chemical pump
- Cylinder – pressed in horizontal position – application piston for chemical pump – ground and polished to rectify imperfect cylindrical shape from uni-axial dry pressing density gradients.



4. Dry Pressing – Cold Isostatic Pressing (CIP)

- Alumina tube – end pieces are sintered onto the cylinder in a second step – translucent indicating very high density >99.8% and high quality for application in high pressure sodium lamps
- Alumina spheres and cups for application in artificial hip joints – again high quality ceramic for lifetimes of 15-20 yeras in the body.
- The rubber silicon mould used to make the green body – mould filled with powder – closed – sealed in a plastic bag when used in an oil pressure vessel or simply used when gas is the compression fluid – week 11 slide 16



5. Slip Casting

- ZrO_2 – white vase – complex shape and 10 cm…cannot form by dry pressing
- Si_3N_4 – silicon nitride – dark grey piston for formula 1 car engine- can run combustion of fuel at higher temperature and thus increase engine power. Too expensive for normal automobile…
- Large complex shapes e.g. wash basin….week 11 slides 24-25

6. Tape Casting

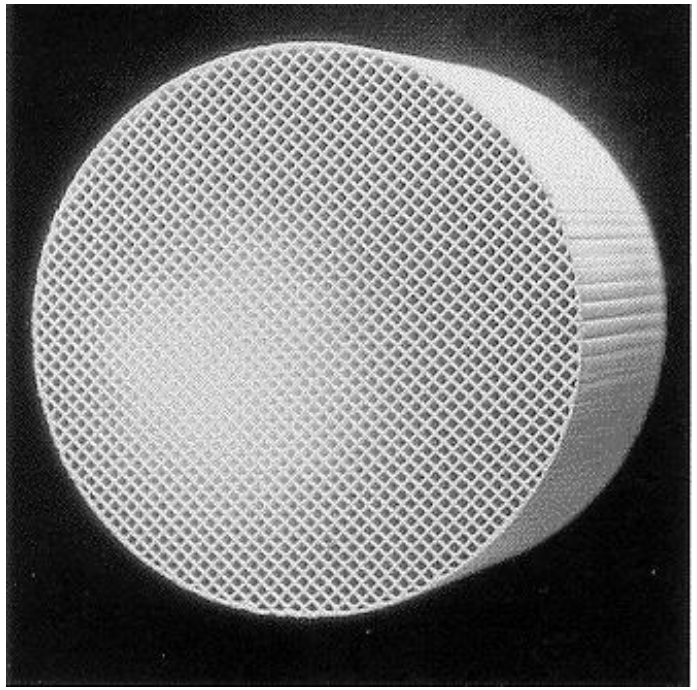
- Solid Oxide Fuel Cell – SOFC – from the Hexis company (CH) week 11 slide 35 – multilayer fuel cell battery
- Video - http://www.youtube.com/watch?v=zE_t5Lsyex8
- Flexible Blue tape – Al_2O_3 with organic pigment – used for electronic substrate applications …see slides week 11 – slides 31-34

7. Plastic Forming - Potters Wheel - Jiggering

- Earthen ware Vase – e.g. ball clay – potters wheel - decorated and glazed after first firing –
- Cup and saucer – a wet disc (cake) from filter pressing – pressed between two shaped plates – saucer – or piston and socket – cup – mug….(sometimes called jiggering)
- Video - Ceramic mugs -2min 33secs https://www.youtube.com/watch?v=pYw5zUyiS7M

8. Plastic Forming - Extrusion

- Corderiete – automobile catalyst support –
- kaolin (70%) talc (30%) to make synthetic cordierite by extrusion for automobile catalyst support – week 3 – slide 12 & week 11 slide 36 – plastic forming - extrusion
- Building bricks – a classic example
- Video of fabrication of bricks
- https://www.youtube.com/watch?v=GEvoXuFKSA0

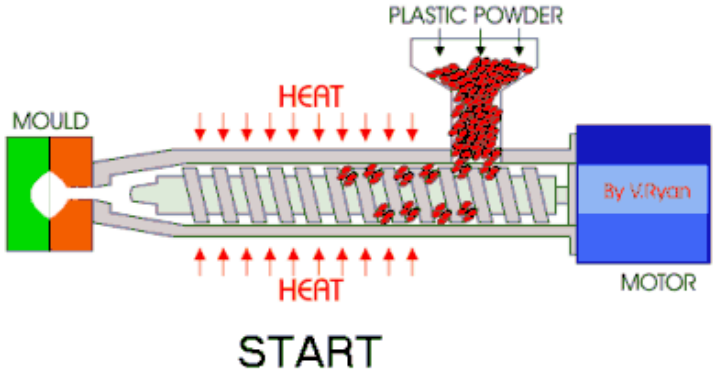


9. Plastic forming – Injection Moulding

- All zirconia ceramics – complex shape orthogonal features

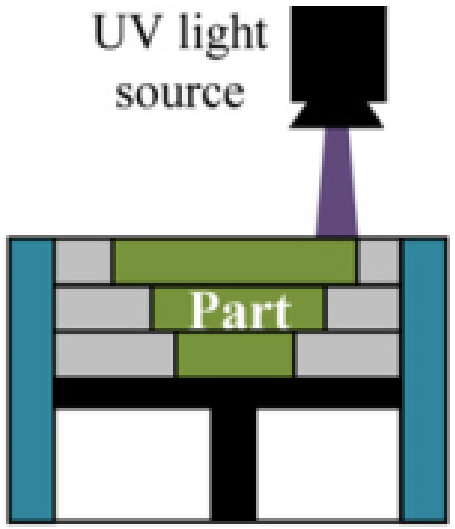
1. Nozzle for soldering in electronic circuits –
2. Nozzle for water spray
3. Dental screws and braces (translucent – high density > 99.8%)
4. Static mixer – used to mix liquids e.g. for rapid production of supersaturation in precipitation experiments – again plates at orthogonal angles – impossible to dry press.
5. Nozzle for high pressure water jet for cleaning buildings

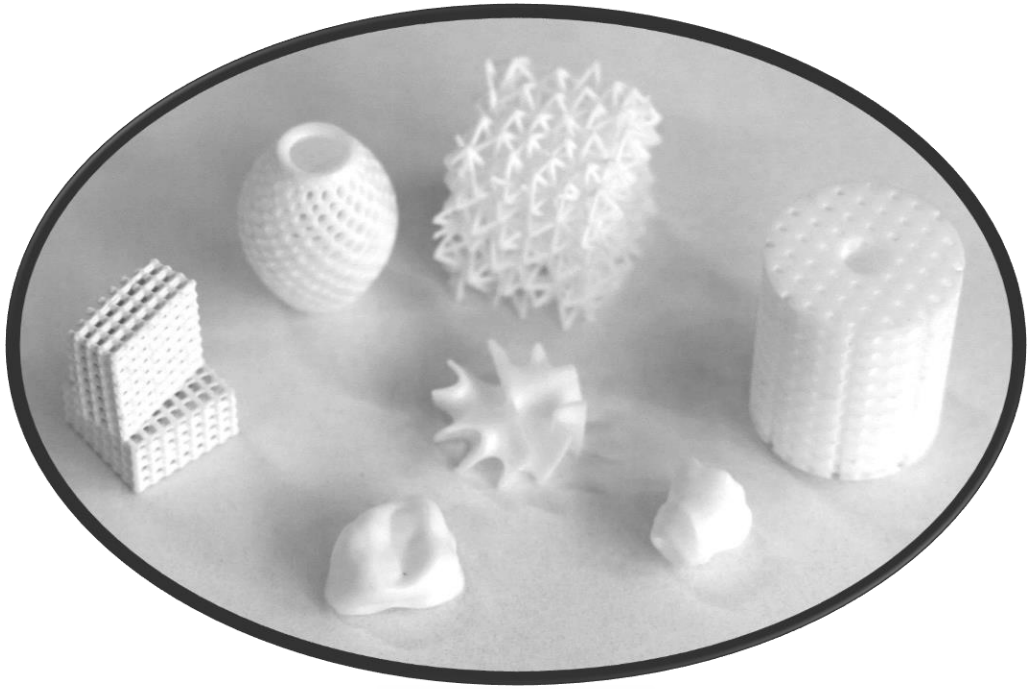
Nozzles



10. Additive Manufacturing - Stereolithography

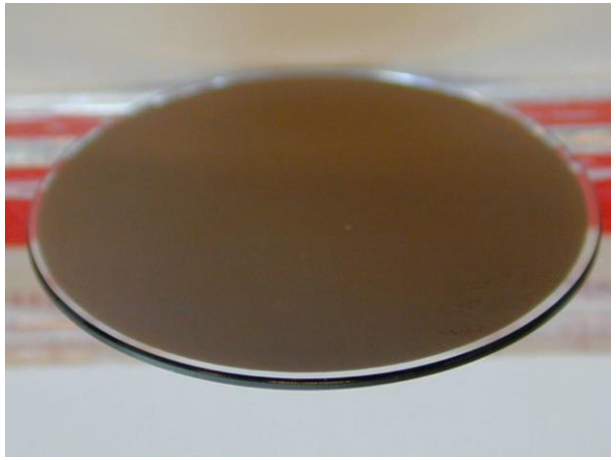
- 1. Biomedical implant – Al_2O_3 – bone support matrix
- 2. Multi-cog wheel for minutarised motor or mini-pump
- 3. ZrO_2 screws for dental applications



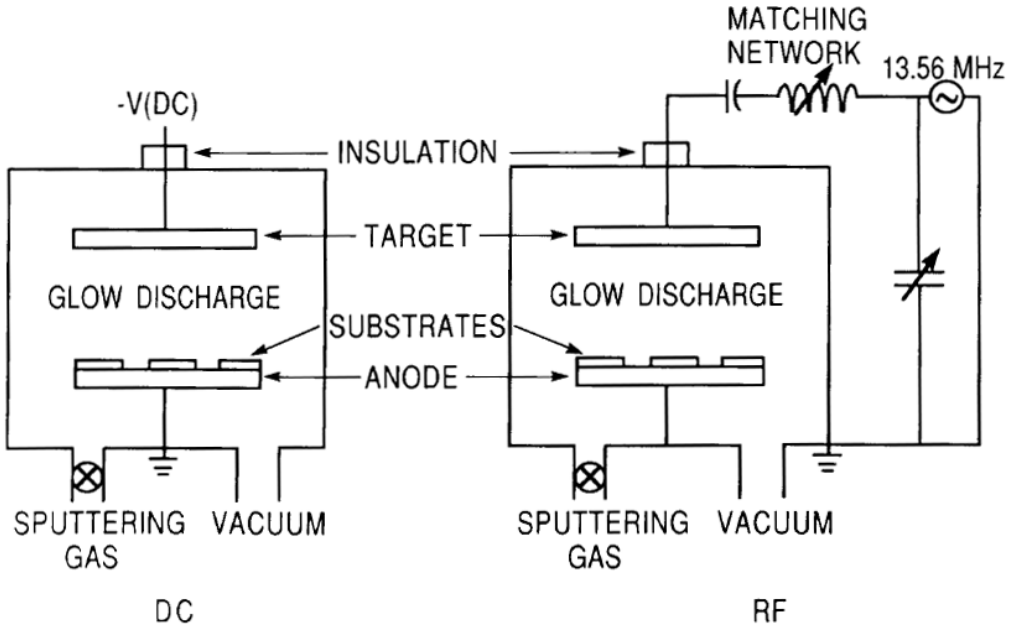


11. Thin Films – Vapour deposition

- TiN thin film on a sapphire (single crystal Al_2O_3) substrate-
- Physical vapour deposition – using e.g. sputtering (ion bombardment) or evaporation of a target.
- Application – decorative or as diffusion barrier or improved surface hardness or wear resistance



Ti N



12. Surfactants and Colloidal Dispersion

- Anethol based beverages – Pernod – Ouzo - happy in 45vol.% ethanol solution – but if mixed with water – forms emulsion –
- can use a surfactant (soap) to redisperse the emulsion by adsorbing at the anethol – water interface – micelle type interaction (week 9 slides 33-36)
- Important for steric stability that adsorbed polymer is in a good solvent (week 9 - slides 22-24