Mühendislik Malzemeleri

Seramikler

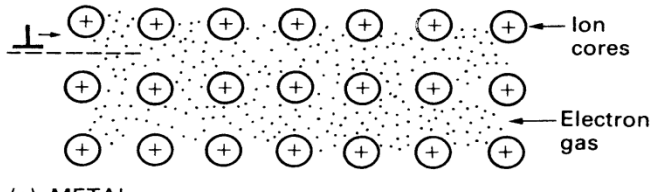
Seramikler

İçerik:

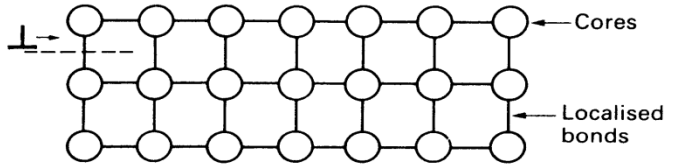
- Deformasyon Mekanizması
- Seramiklerin gevrek kırılması
- Mukavemet
- Üretim
- Uygulamalar

Deformasyon Mekanizması

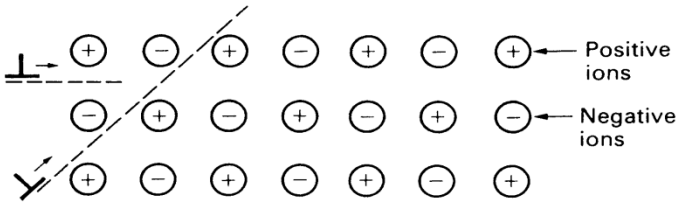
- Dislokasyon hareketi metallere göre kovalent ve iyonik bağa sahip kristalli yapılarda daha zordur
- Güçlü bağlar nedeniyle Elastik modül yüksektir



Metal



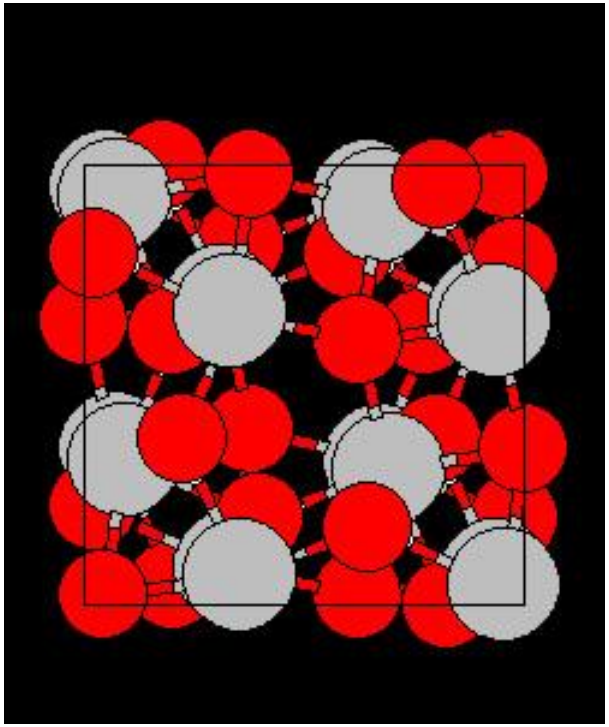
Covalent Ceramic



Ionic Ceramic

Deformasyon Mekanizması

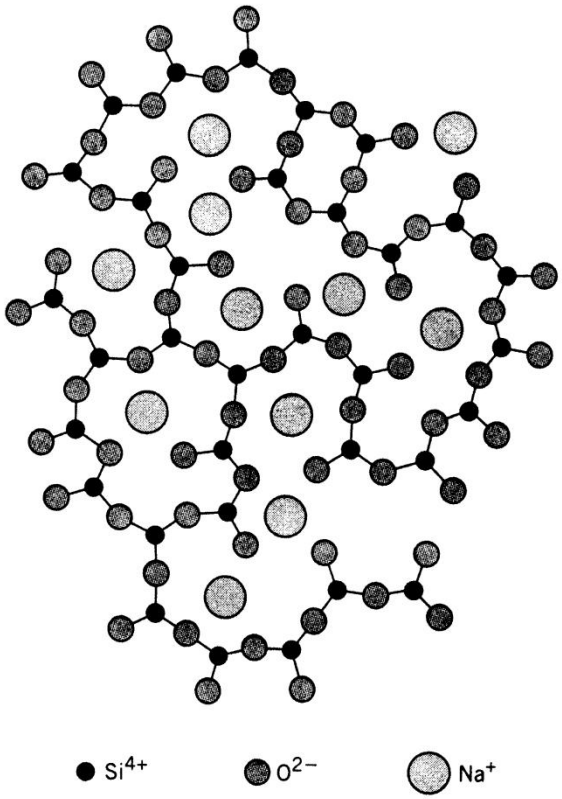
- There are limited numbers of slip systems available in the complicated crystal structures of most ceramics.
- Some slip systems only become active at high temperatures



Alumina Crystal Structure

Deformasyon Mekanizması

- Dislocation glide is difficult in the disordered structure of glasses
- Glasses may deform by viscous flow, but viscosity is very high at ambient temperatures



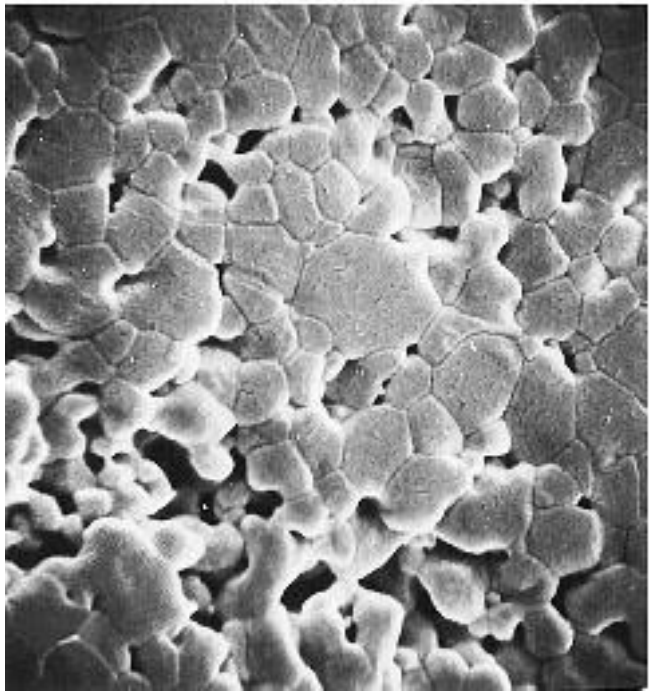
Brittle Fracture of Ceramics

- Defects in ceramics can develop due to internal stresses and porosity
- Thermal stresses due to an-isotropic thermal expansion tend to crack weak grain boundaries

96% dense alumina

Seramiklerin Gevrek Kırılması

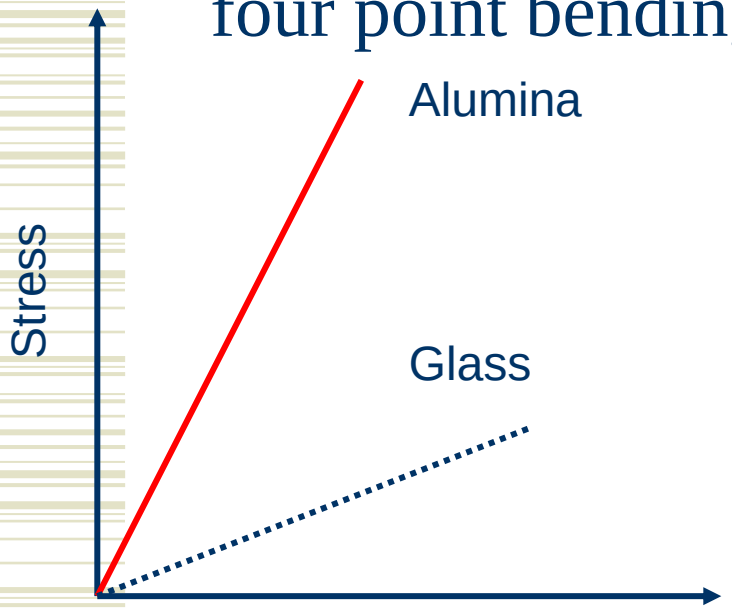
- Defects in ceramics can develop due to internal stresses and porosity
- Thermal stresses due to an-isotropic thermal expansion tend to crack weak grain boundaries

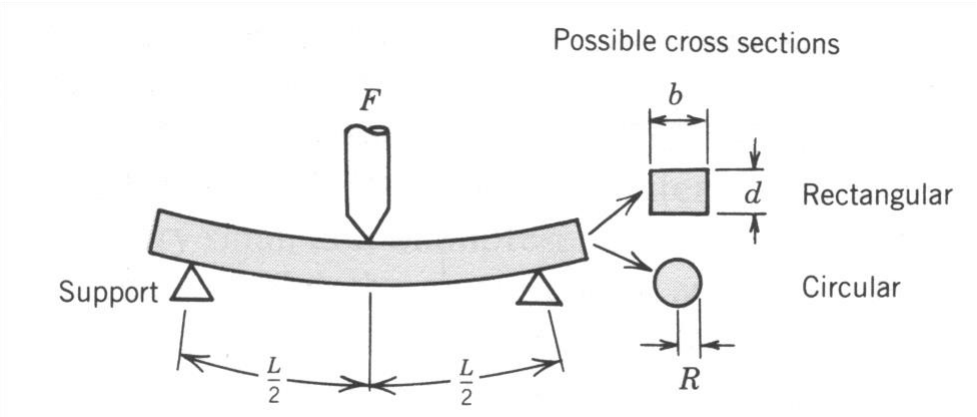


Pores in partially sintered Alumina

Mukavemet

- **Modulus of Rupture**
- Measured in three or four point bending



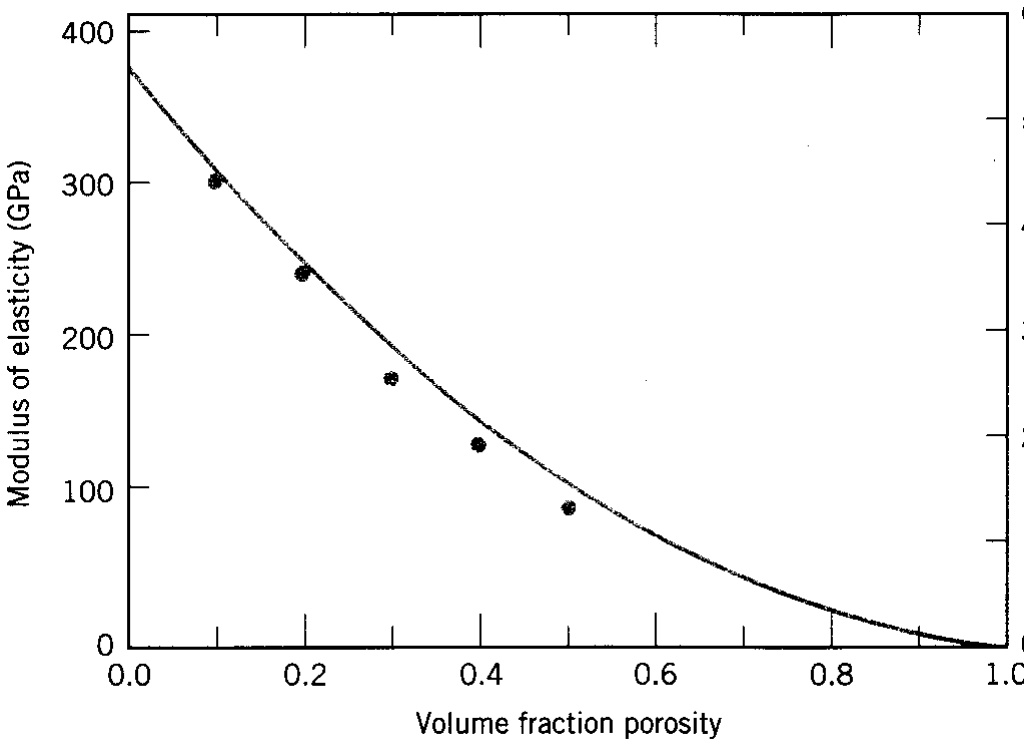


Fracture data is scattered
Scatter described using statistics, such as Weibull Modulus

Failure strains typically <0.1%

Boşluk Etkisi

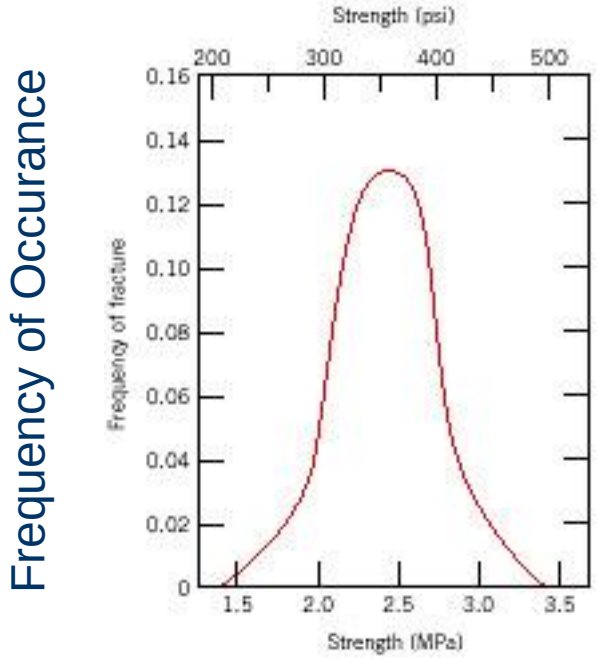
- Elastik Modül
- Boşuklar elastik modülü düşürür



Elastic modulus of Alumina

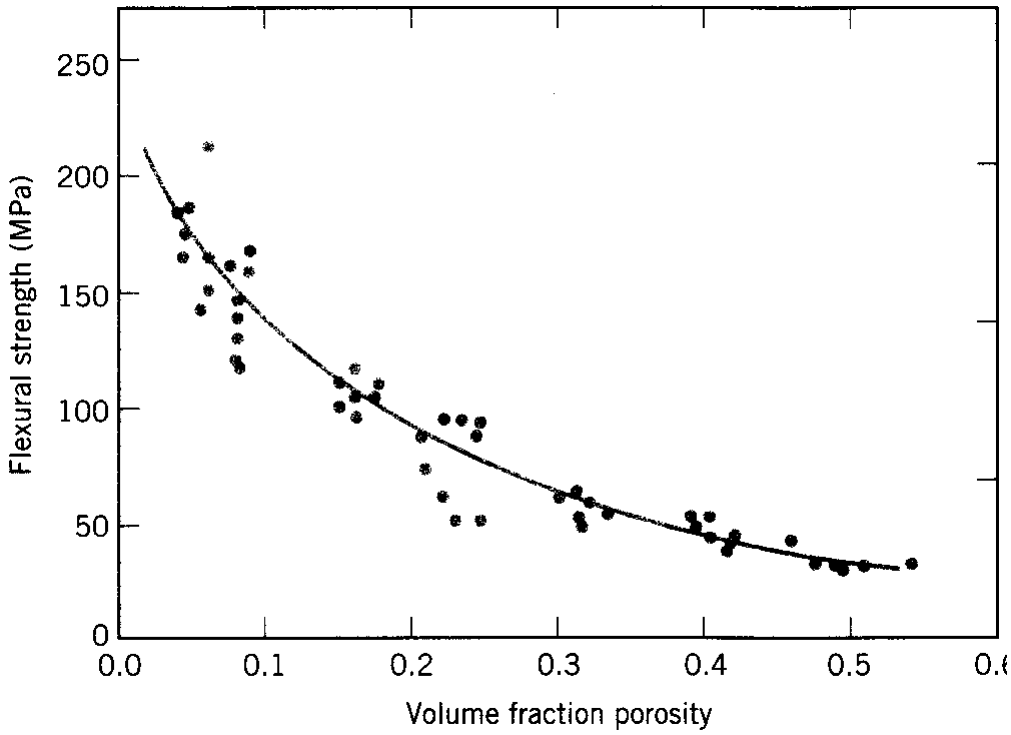
Boşluk Etkisi

- Flexural Strength is variable and affected by porosity



Frequency of Occurance

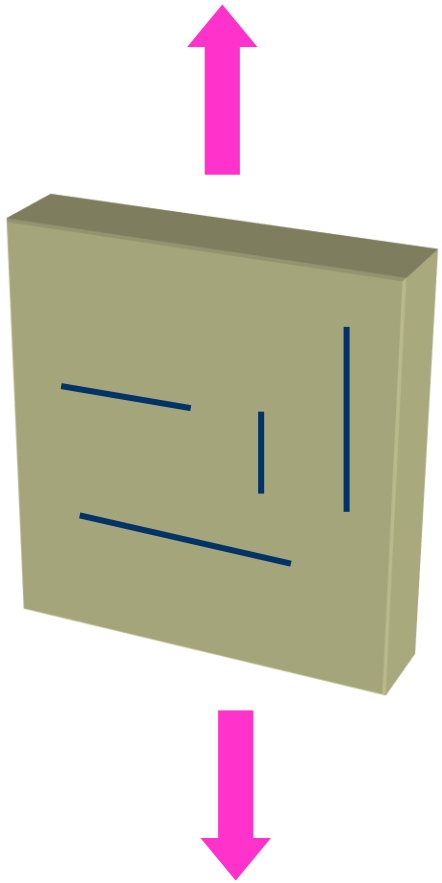
Strength



Flexural strength of Alumina

Deformasyon İstatistiği

- **En Zayıf bağlantı**
- The strength of a component depends on the population of defects



Kırılma Mekanizması

- Kırılma mukavemeti en büyük kusurun ebadına bağlıdır

$$\sigma_f = \sqrt{EG_c / \pi a}$$

Work of fracture: G_c
Çatlak boyu, a
Elastik modül, E
Termal genleşme sabiti, α
Sıcaklık değişimi, ΔT

$$E\alpha\Delta T = \sigma_f$$

Typical defects include porosity and cracked grain boundaries

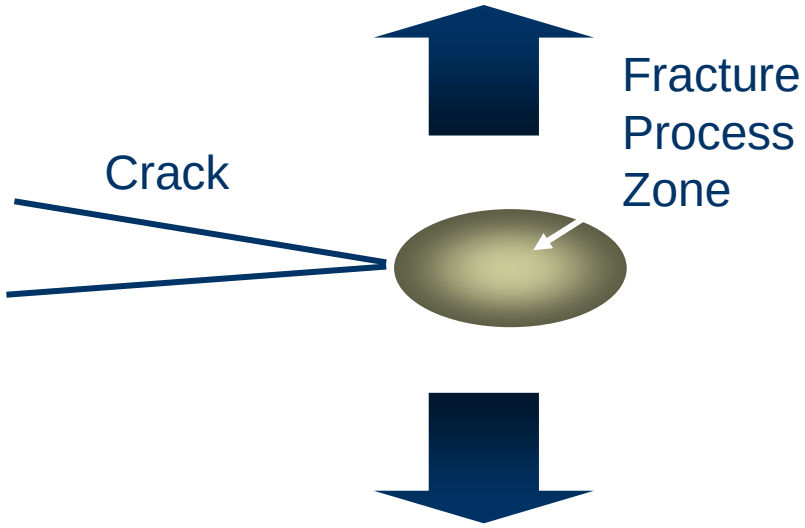
Thermal strains due to high processing temperatures and low ductility can give high internal stresses between grains, which may fracture grain boundaries

Kırılma Mekanizması

- Kırılma mekanizması malzemenin kırılması için gereken enerjiyi etkiler.

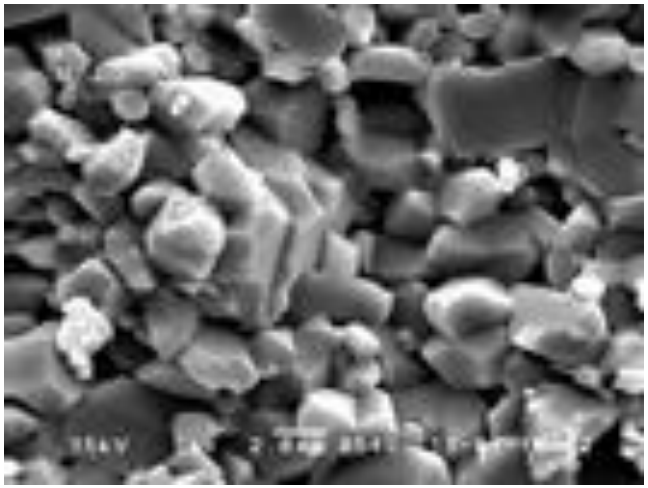
Work is done in the
Fracture Process Zone

The strength of ceramics is increased by increasing the work of fracture



Seramiklerin Gevrek Kırılması

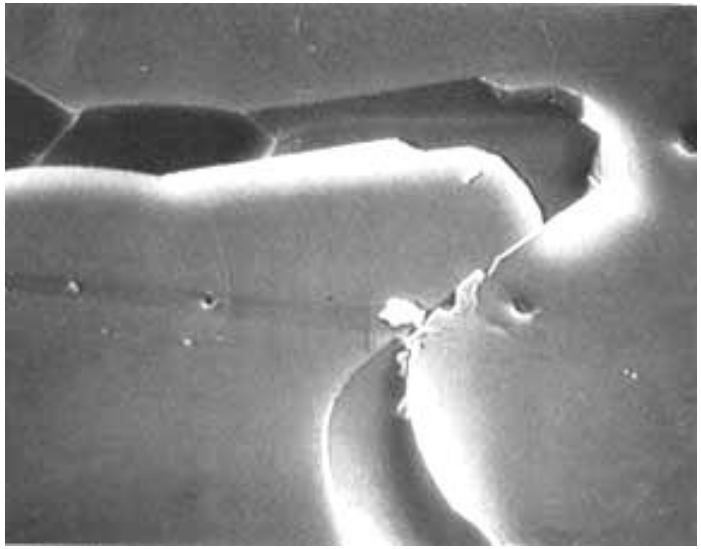
- Fracture may be intergranular, or transgranular
- Cracks propagate along the easiest path
- Intergranular fracture may increase toughness by increasing fracture surface area and grain bridging



Intergranular fracture in alumina

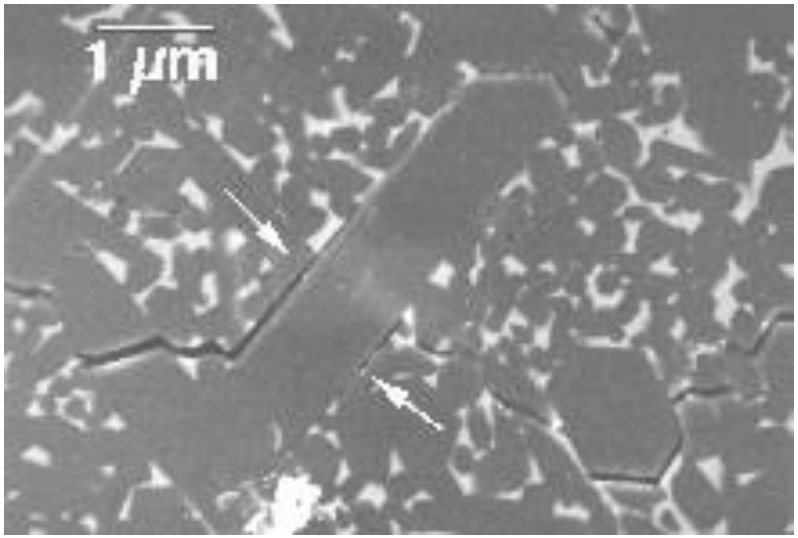
Tokluk Artırma Mekanizması

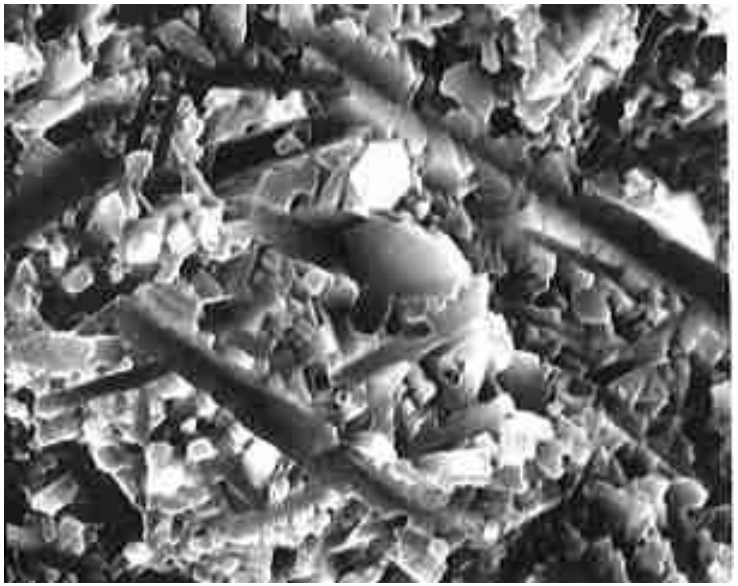
- Crack Bridging increases work of fracture by frictional forces and interlocking of grains.
- Encouraged by intergranular fracture
  - (high internal stress, large grains and weak interfaces)



Silikon Nitrür

- Silicon nitride microstructures have strong R-curve behaviour due to crack bridging and crack deflection by needle-shaped grains

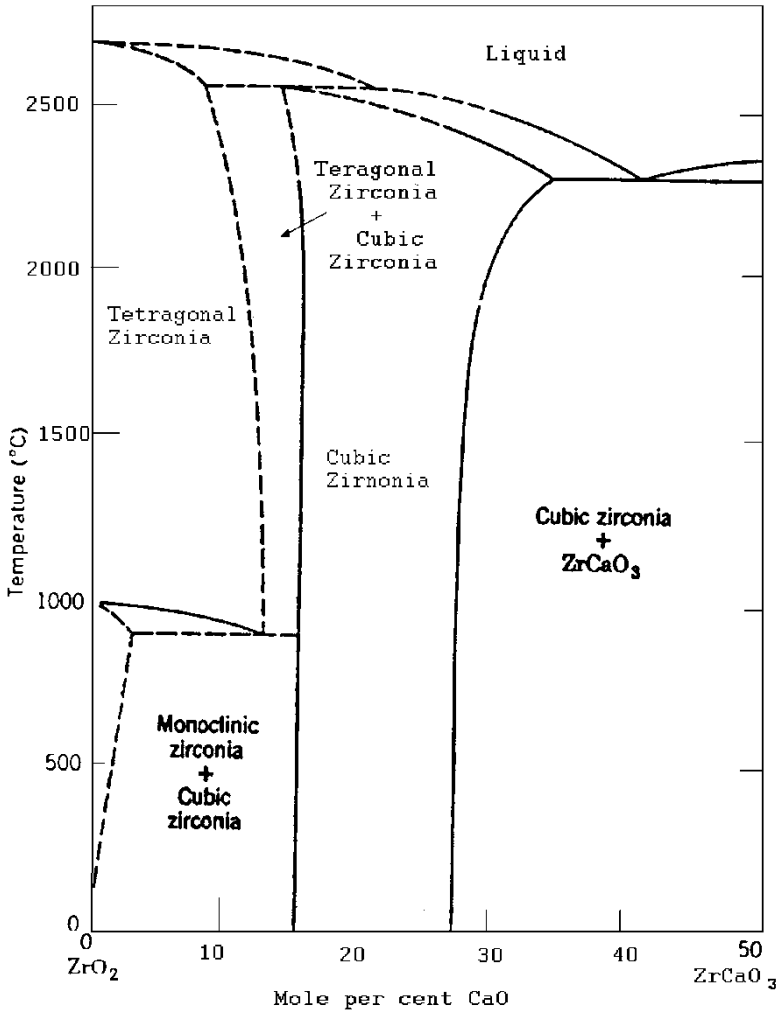




Silicon Nitride

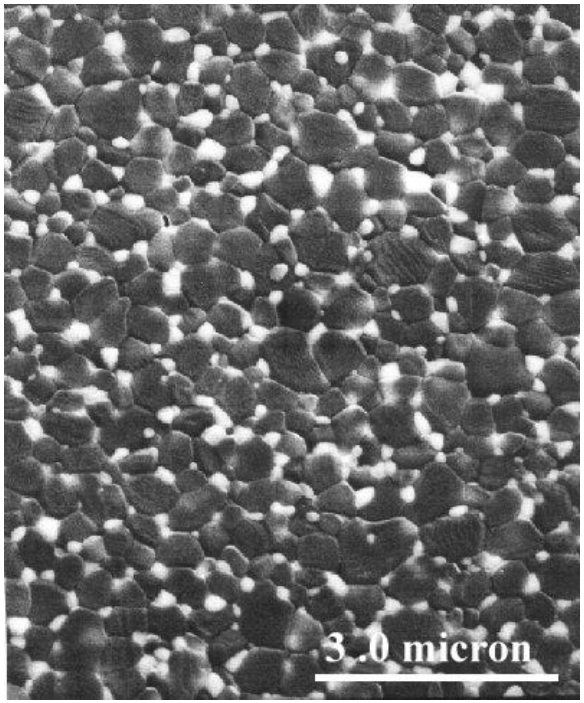
Kısmi Kararlı Zirconia (PSZ`

- Additions (Ca,Mg etc) to zirconia give metastable tetragonal zirconia and cubic zirconia.
- Stress-induced transformation of tetragonal to monoclinic causes microcracking and increases the work of fracture



Zirkon ile Takviyeli Alumüna (ZTA)

- Zirconia may be added to alumina to give a ceramic composite
- Stress induced transformation of the zirconia increases the toughness and wear resistance



Zirconia toughened alumina

Zirconia Toughened Alumina (ZTA)

Zirconia toughened alumina

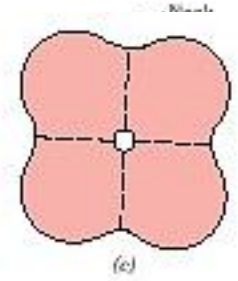
Zirconia toughened alumina

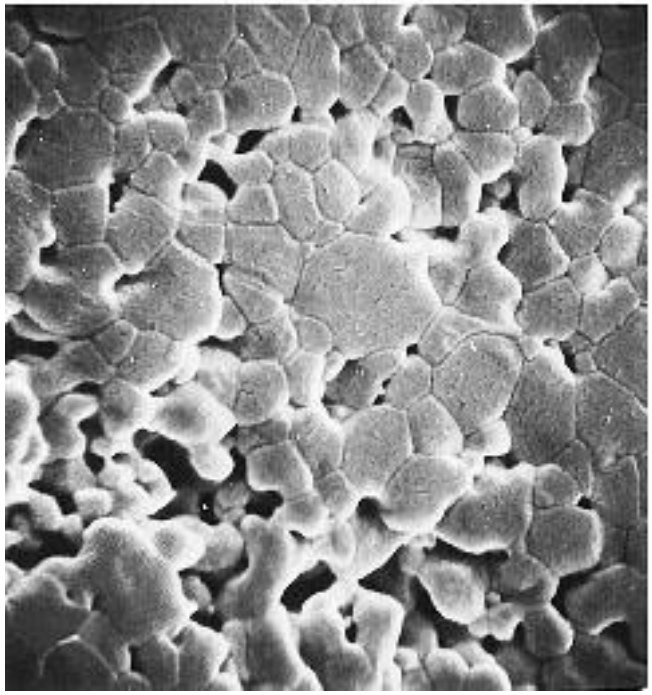
Tipik Özellikler

Material	Flexural Strength (MPa)	Elastic Modulus (GPa)
Silicon Nitride	800	300
Partially Stabilised Zirconia	630	200
Alumina	300-500	400
Silicon Carbide	500-800	430
Glass	70	70

Geliştirilmiş Seramiklerin Üretimi

- Sintering (hot pressing) bonds ceramic particles by diffusion
- Glassy phases increase sintering rate and decrease porosity



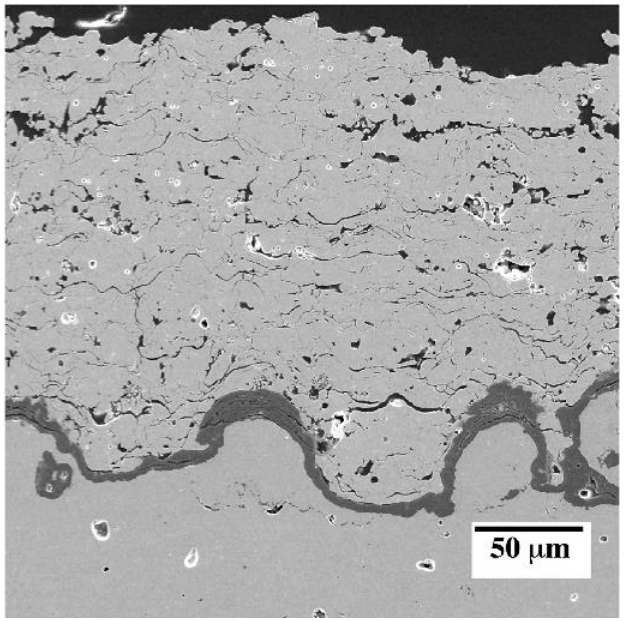


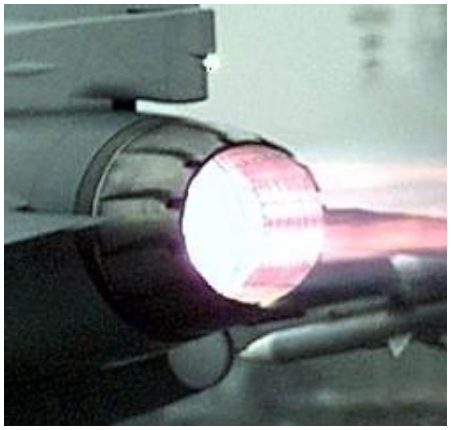
Pores in partially sintered Alumina

Uygulamalar

Thermal Barrier Coatings

Low thermal conductivity
reduces metal temperatures



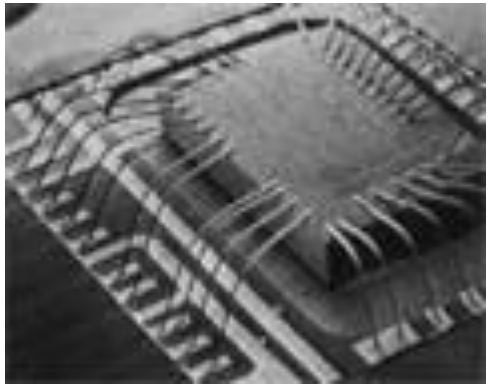


Uygulamalar

Electronics Packaging

Ceramics provide high temperature performance and thermal expansion coefficient match to Silicon

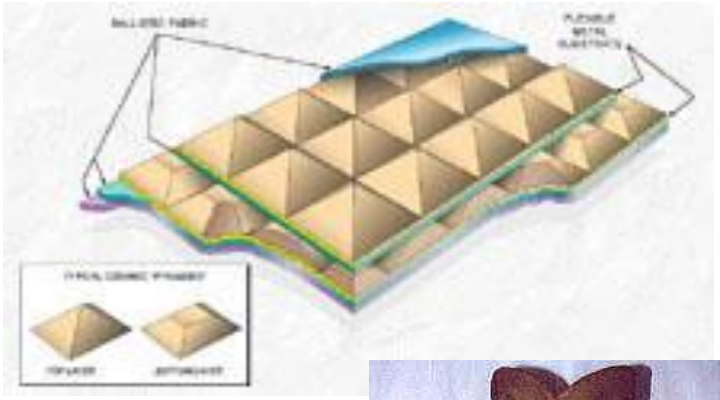
High thermal conductivity desired (e.g. AlN)

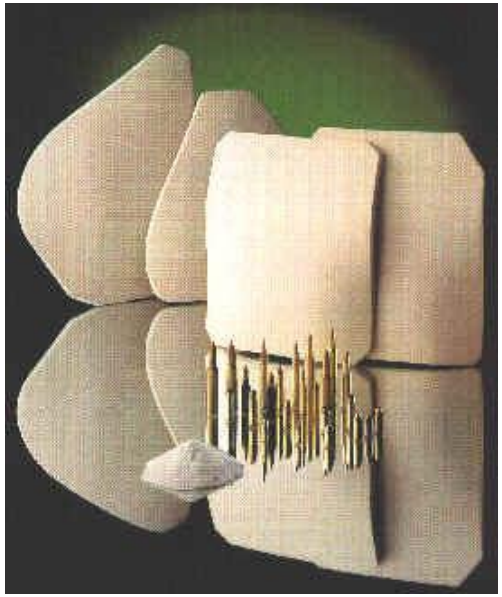


Uygulamalar

Ceramic Armour

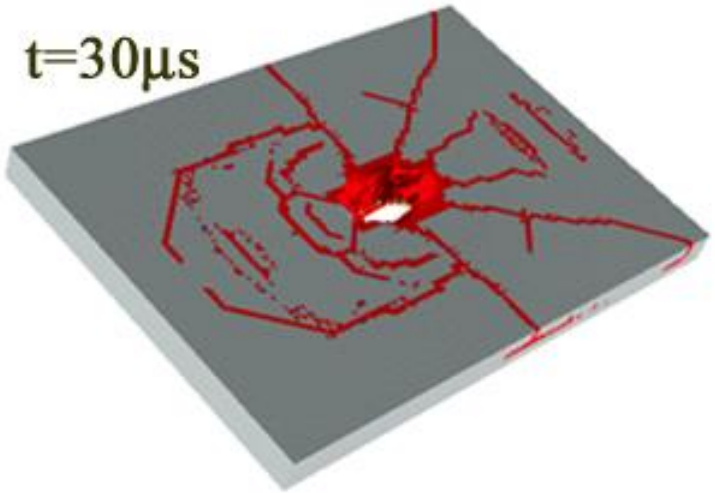
Absorption of projectile energy

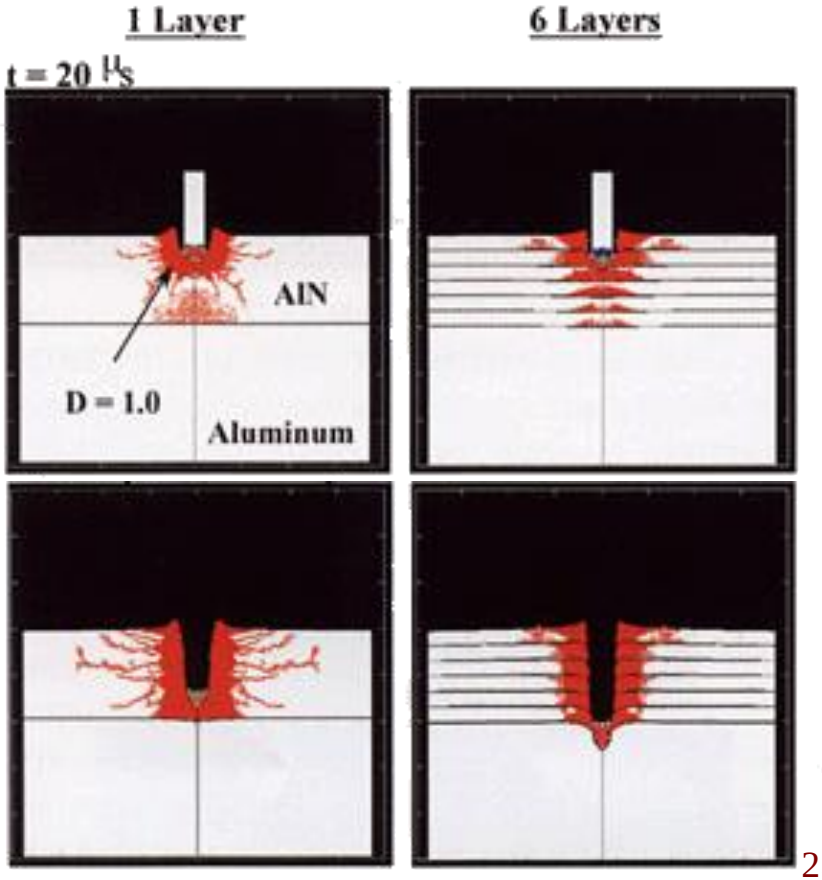




Uygulamalar

Seramik Armour





Multi-Tabakalı Yapılar

özet

- The mechanical properties of ceramics differ considerably from metals due to their relative inability to deform plastically.
- Strength of ceramics is strongly affected by internal defects.
- Strength can be optimised by additions and control of microstructure.