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Processing ZnO Powder to Support Compaction Modeling

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Starting Materials

The 0.2 µm ZnO powder is weighed out and mixed with DI water and a dispersant.

The creation of a dilute slurry aids in deagglomeration.

Deagglomeration

The slurry is ultrasonicated to break the agglomerates into individual particles.

Poorly dispersed particles will lead to irregular compaction behavior and non-uniform microstructure.

Binder Addition

A 3 wt% PVA/PEG binder is added to the slurry followed by ultrasonication

The binder lubricates and strengthens the green body

Drying

The water is driven off in a drying furnace at 70°C.

Stirring the slurry maintains homogenous density and composition.

Granulation

The dried powder is granulated in a high speed impact mill.

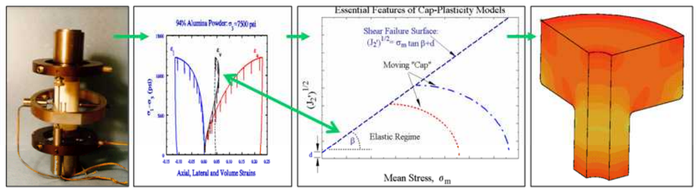
This step determines the granule size distribution of the powder.

Background

The implementation of compaction modeling software requires an understanding of the constitutive properties of a ceramic powder. To accomplish this, 0.2 µm ZnO was processed, pre-formed, and cold isostatic pressed (CIPed) into 2.5 cm x 3 cm slugs. These slugs were subjected to hydrostatic and tri-axial testing to determine the compaction parameters needed for the model.

This poster depicts the steps involved in the processing, forming, and testing of the powder. The agreement between the computer predicted behavior and the observed compaction validates this technique.

Tri-Axial Testing



Tri-axial testing generates a plot of axial, radial, and volumetric strain of the powder compact. The inflection point on the volumetric strain curve reveals the stress state that corresponds to the shift from the elastic to plastic regime and defines the shear failure surface. When combined with the "cap" stress, it is used to model density as a function of stress state within finite element compaction models.

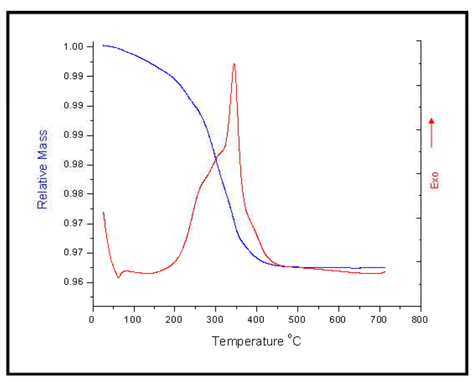
Summation

This process is followed in order to yield a powder that presses properly under minimal loading which results in a sintered body with a uniform microstructure.

The desired compact qualities can only be achieved if the process accomplishes the following:

- Complete and uniform particle dispersion
- Optimal granule size distribution
- Minimal density gradients

TGA / DTA Plot



The thermogravimetric and differential thermal analysis plot shows the uniform binder burnout characteristics of the granulated powder.

Uniform binder burnout is important for maintaining the integrity of fine grained ceramic compacts.

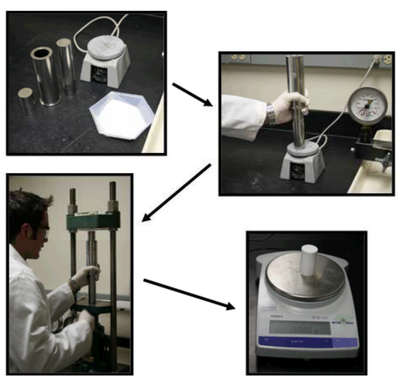
Sieving

The granules are separated according to size with sieves.

Large granules flow easily. Small granules tend to cake. Both result in irregular pore structures.

Powders containing granules between 25 and 75 µm tend to press optimally.

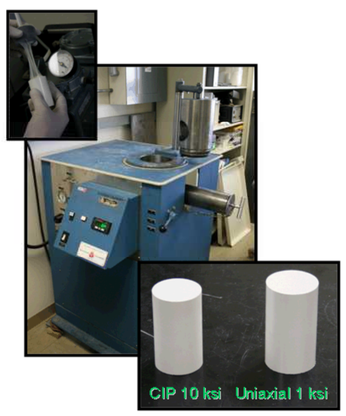
Pressing



Powder is precisely weighed out, vibration packed, and uniaxially pressed into slugs.

Careful die filling and pressing are critical for reproducible densities.

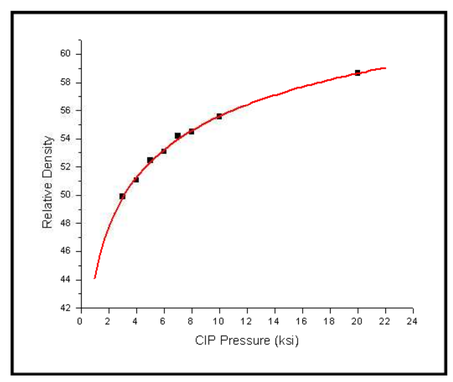
Cold Isostatic Pressing



Each of the identically uniaxially pressed slugs are vacuum sealed and CIPed to incremental densities.

The CIPed slugs are the machined into identical right cylinders for use in tri-axial testing

CIPed Density Plot



This plot shows the effect of CIP pressure on relative density.

The large smooth asymptotic density change from pre-formed to 10 ksi CIPed is typical of a high-quality pressing powder

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