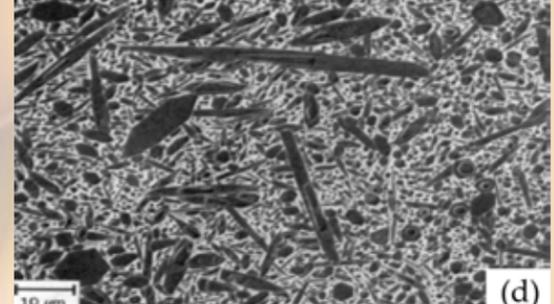


## WHAT IS SILICON NITRIDE?

Silicon nitride ( $\text{Si}_3\text{N}_4$ ) is an extremely strong and robust material that can be used at high temperatures (upwards of  $1000^\circ\text{C}$ ). It is commonly used in high-speed jet engines, car engines, and even skateboards.  $\text{Si}_3\text{N}_4$  is often made into ball bearings due to its wear and corrosion resistance, and was even used in one of the main engines of NASA's space shuttle.

# PROCESSING ONE OF THE WORLD'S HARDEST MATERIALS

## WHAT DOES IT LOOK LIKE?

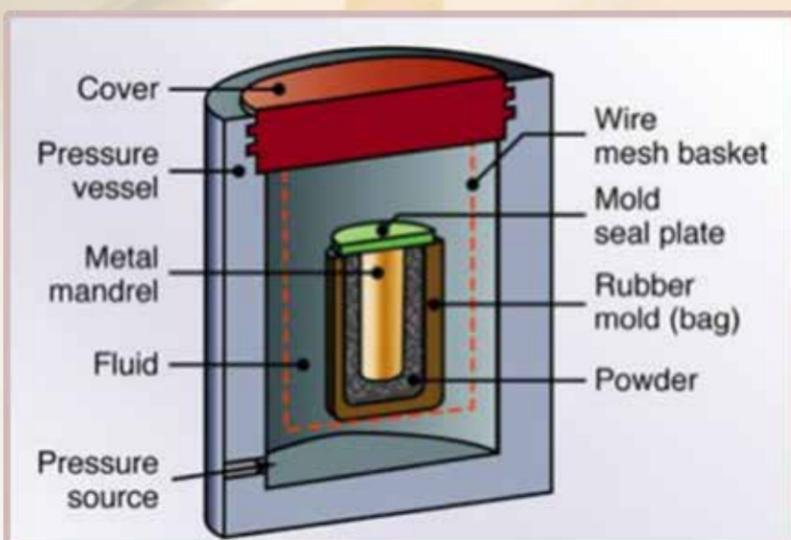


(a) Silicon nitride is often made into ball bearings to assist in rotation and reduce friction in rotating machinery. (b) The ball bearings can be implemented in axle systems. (c) The material can be made into a variety of useful shapes for high-temperature applications. (d) We are able to see how the needle-like grains are arranged on a fine scale by using advanced microscopes.

## HOW IS IT MADE?

$\text{Si}_3\text{N}_4$  is difficult to shape into usable parts. Luckily, scientists have designed a way to manufacture ball bearings out of this material. The process of making nearly perfect  $\text{Si}_3\text{N}_4$  spheres is shown below.

1. Precursor chemicals that contain silicon and nitrogen are mixed together and dried, leaving  $\text{Si}(\text{NH})_2$ .
2. To remove the hydrogen, the powder is heated to  $1200^\circ\text{C}$  in a process called calcination.
3. The remaining  $\text{Si}_3\text{N}_4$  powder is heated to  $1350^\circ\text{C}$  to crystallize. It may be mixed with other elements in a room-temperature slurry before ball milling.



Cold isostatic pressing allows the fluid to uniformly compact the particles into a sphere.

4. The resulting smaller, dried particles are ready to be loaded into a cold isostatic press (CIP).
5. The powder is pressed together under uniform, extreme pressure in a dry bag mold surrounded by liquid.
6. The part may be ground to smoothen the surface before sintering in a furnace at  $1700\text{--}1800^\circ\text{C}$  to promote chemical reaction and densification.

## SUMMARY

$\text{Si}_3\text{N}_4$  is a material crucial to the success of future state-of-the-art vehicles. It has many promising properties but requires careful consideration of processing and manufacturing challenges. Scientists have even recently discovered how to make transparent  $\text{Si}_3\text{N}_4$ . Want to learn more? Visit [www.ceramics.org](http://www.ceramics.org)