Technical Ceramics

Advanced Material Solutions

Billions of Connections, One Solution

Skyworks has been enabling wireless connectivity for over a decade. However, given growing consumer demand for wireless ubiquity and the desire for anytime, anywhere access, there are billions of connections yet to be made.

With our high-performance analog semiconductors, Skyworks is linking people, places, and things across a growing number of markets and applications – bringing everyone closer to vital information wherever it is needed.

Skyworks is a global company with engineering, marketing, operations, sales and support facilities located throughout Asia, Europe and North America. For more information, please visit Skyworks' website at www.skyworksinc.com.

A Leader in Advanced Technical Ceramics

Skyworks Solutions, through its wholly-owned subsidiary Trans-Tech, is the industry leader in technical ceramics. With over 60 years of experience, we offer a complete line of high quality, low-cost ceramic-based materials for a number of RF and microwave markets including wireless communications, infrastructure, military, cable television and broadband access. Our tightly controlled processes—from raw materials to forming, firing, finishing, assembly and test—produce the highest quality and the most consistently reproducible components available today for both low and high volume requirements. Our portfolio includes dielectric resonators and coaxial transmission line elements for dielectric resonator oscillator (DRO) and voltage-controlled oscillator (VCO) applications, ceramic bandpass filters, ferrite and garnet material for circulators/isolators, and advanced materials in technical powders or ingot form.

Our in-house manufacturing capability enables us to deliver materials ranging from custom particle size distributions for thermal barrier coatings and fuel cells, to machined precision components.

Table of Contents

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Advanced Materials

| Microwave Absorbers and Dielectric Modifiers

Our Advanced Materials portfolio offers a variety of magnetic absorber powders operating at a frequency range from 1 MHz to several GHz.

Advantages of Hexagonal Ferrites for Microwave Absorbers

For an incident electromagnetic wave, the surface of a conductor cannot support a transverse electric field because the electric field is maximized at a quarter wave above the surface. Conversely, the maximum of the magnetic field occurs at the surface of a conductor. In order to be placed at the maximum field for utmost effectiveness, an absorber, which works on electrical properties such as silicone rubber loaded with carbon particles, must be at least a quarter-wavelength thick. Many commercially available magnetic absorbers create eddy currents in a magnetic conductor, such as iron. The eddy currents then act as the loss mechanism. Conductive materials can create unwanted reflections of electromagnetic waves. An absorber, which works on magnetic principles, can be much thinner since the interaction is maximized at the surface.

- The loss mechanism of our hexagonal ferrites lies in the inherent loss factor of the materials at high frequencies – the materials are nonconductive.
- By controlling chemistry and processing, the loss characteristics can be tailored to the customer's needs for a specific application frequency.
- In many cases, dispersing magnetic absorber powders in a polymer matrix can tailor the dielectric constant and magnetic permeability, adjusting the impedance of the absorber to further minimize reflections.

Custom Powder Compositions and Morphologies

| Medical Materials

We offer high-quality powders of hydroxylapatite and beta-tricalcium phosphate for specialty medical applications including feedstock for natural human bone cell growth. Powders can be milled (1-5 micron) or plasma sprayable (custom particle size).

Our industry proven biomedical materials are backed by years of commercial use and extensive process refinement.

Biomedical Materials

Hydroxylapatite $Ca_{10}(PO_4)_6(OH)_2$
βTCP $Ca_3(PO_4)$

Custom Powders and Thermal Barrier Ingots

Advanced Materials

| Thermal and Environmental Barrier Coatings

With our in-house manufacturing capability, we can deliver materials that range from custom particle size distributions for thermal barrier coatings and fuel cells, to machined precision components.

Our ingots continue to be the industry standard for EB-PVD. Our material purity, controlled processing, and uniform density provide a controlled meltpool with minimal eruptions and spitting.
As a result, we are your source for advanced, state-of-the art, low thermal conductivity ingots and powders.

Ingots for EB-PVD

- PWA 36361 (approved supplier)
- GE A50TF299 (approved supplier)
- Custom compositions, including the challenging pyrochlore-forming rare earth zirconates and hafnate

Thermal Spray Powders

- PWA 1375 (conforms)
- GE A50TF278 (conforms)
- Custom compositions
- Our spray dry and sinter manufacturing process produces structurally stable spherical particles with excellent flow properties and high chemical purity

Custom Powders and Thermal Barrier Ingots

| Solid Oxide Fuel Cells (SOFC)

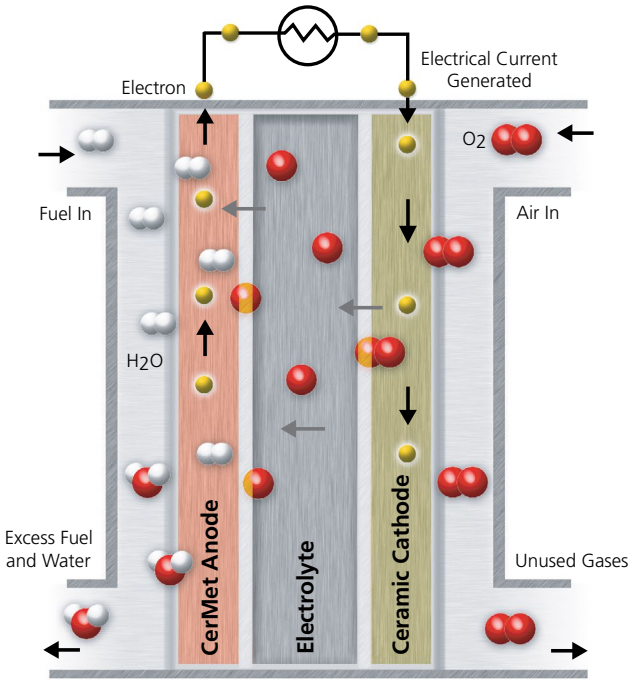
With cost levels set for the commercialization of solid oxide fuel cells, our low-cost, solid-state reaction manufacturing process can help achieve your goals. We offer the complete ceramic oxide solution:

Cathode: Conductive perovskites, including alkaline-earth doped lanthanide manganites, cobaltite, nickelates and ferrites, as well as solid solutions of the above compositions

Electrolyte: Stabilized zirconia (YSZ), as well as lanthanide or yttria doped ceria

Anode Powder: Homogeneous blend of nickel oxide, YSZ, and specialty formulations

Interconnects: Lanthanide chromites and specialty ceramic formulations



SOFC Cathode, Anode and Electrolyte

Advanced Materials

| Powders

Our experts in the field of ceramic powder processing can produce a broad range of oxide ceramic compositions tailored to your specific chemistry and particle characteristic requirements. With more than 60 years of experience in manufacturing one of the most comprehensive oxide ceramic product offerings worldwide, we can deliver a consistent, high quality product at a reasonable cost. If you don't find what you need below, contact us at rfceramics@skyworksinc.com. We can probably make it!

Thermal Barrier Coatings

Yttria Stabilized Zirconia

Monoclinic Lanthanum Aluminate oxides

Barium Neodymium Titanate based powders

Cubic or tetragonal Stabilized Zirconia
– *with multiple stabilizer options*

Cubic or tetragonal Stabilized Hafnia
– *with multiple stabilizer options*

Solid solutions of the above Zirconias and Hafnias

Lanthanide Zirconate Pyrochlores
– *provides lower thermal conductivity*

Lanthanide Hafnate Pyrochlores
– *provides higher operating temperatures*

$LaYbO_3$ or other Interlanthanide Perovskites

$Ln_3Ta(Nb)O_7$ Pyrochlores

Environmental Barrier Coatings

Barium Strontium Aluminum Silicate

Ytterbium Silicate

Lutetium Silicate

Mullite

Solid Oxide Fuel Cell Materials

Manganites

Ferrites

Ferrite-Cobaltites

Cobaltites

Doped Ceria

Proton Conductors
$BaZr_{(1-x)}Y_xO_{3-1/2x}$
$BaCe_{(1-x)}Y_xO_{3-1/2x}$

Specialty Aluminate Powders

Garnets
$Y_3Al_5O_{12}$ (YAG)
$Y_3Al_5O_{12}:Ln^{3+}$ (doped-YAG)
$Ln_3Al_5O_{12}$

Spinels
$MgAl_2O_4$ (pure and doped)
$ZnAl_2O_4$
$M^{II}Al_2O_4$

Perovskites
$YAlO_3$ (YAP)
$LnAlO_3$

Magnetoplumbites
$LnMgAl_{11}O_{19}$
$LnZnAl_{11}O_{19}$

Specialty Aluminum Oxides
$LiAlO_2$
Cordierite

Dielectric Oxides
$Ba_{1-x}Sr_xTiO_3$
$BaZrO_3$
Ba-Ti-O_x Powders
Ba-Ln-Ti-O Powders

Specialty Dielectrics
Titanates, Niobates, Tantalates
$SrZrO_3$
$SrTiO_3$
$CaTiO_3$
$CaCuTi_4O_{12}$

Specialty Hexagonal Ferrite Powders and Ceramic Products

M-Type
$BaFe_{12}O_{19}$
$BaFe_{12-2x}M^{II}_xM^{IV}_xO_{19}$

Z-Type
$Ba_3Co_2Fe_{24}O_{41}$ (Co_2Z)
$Ba_3Zn_2Fe_{24}O_{41}$ (Zn_2Z)
$Ba_3M^{II}_2Fe_{24}O_{41}$ (M^{II}_2Z)

Y-Type
$Ba_2Co_2Fe_{12}O_{22}$
$Ba_2Zn_2Fe_{12}O_{22}$
$Sr_2Co_2Fe_{12}O_{22}$
$Sr_2Zn_2Fe_{12}O_{22}$

W-Type
$BaCo_2Fe_{16}O_{27}$
$BaZn_2Fe_{16}O_{27}$
$BaNi_2Fe_{16}O_{27}$
$BaMn_2Fe_{16}O_{27}$

Biomedical Materials

Hydroxylapatite $Ca_{10}(PO_4)_6(OH)_2$
β-TCP $Ca_3(PO_4)_2$

Advanced Materials

Custom Compositions

Need a custom composition? We have a team of experienced material scientists with expertise in the synthesis and analysis of ceramic oxides. When combined with our in-house analytical capabilities, we are the obvious choice for all your custom composition needs. In addition, our diverse inventory of raw materials and access to a variety of suppliers allow us to secure laboratory batches from one to 100 kilograms in just a few weeks.

Our Capabilities

In-house Analysis

- Scanning electron microscope (SEM) with energy dispersive X-ray capability (EDAX)
- X-ray diffraction (XRD)
- X-ray fluorescence (XRF)
- Particle size distribution using laser light scattering
- Surface area analysis using BET method
- High temperature electrical conductivity (up to 1000 °C)
- Thermogravimetric Analysis (TGA)
- Dilatometer for thermal expansion coefficient determination
- Optical microscopy

Production

Our high volume, solid state reaction manufacturing process allows us to provide low cost materials and large homogeneous batch sizes. Typical powders range in particle sizes (D50) below two microns and have surface areas up to eight m^2/g. Standard forming methods can also be used to produce a variety of custom component shapes.

- Homogeneous lot sizes up to 3600 kgs
- Production capacity in excess of 500,000 kgs per year
- Urethane lined vibratory energy mills with ultra low wear media provide tight particle size distributions while minimizing media contamination
- Batch AND continuous kilns up to 1700 °C in a variety of atmospheres

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For more information about all of our advanced material solutions, please visit us at www.skyworksinc.com/technicalceramics.

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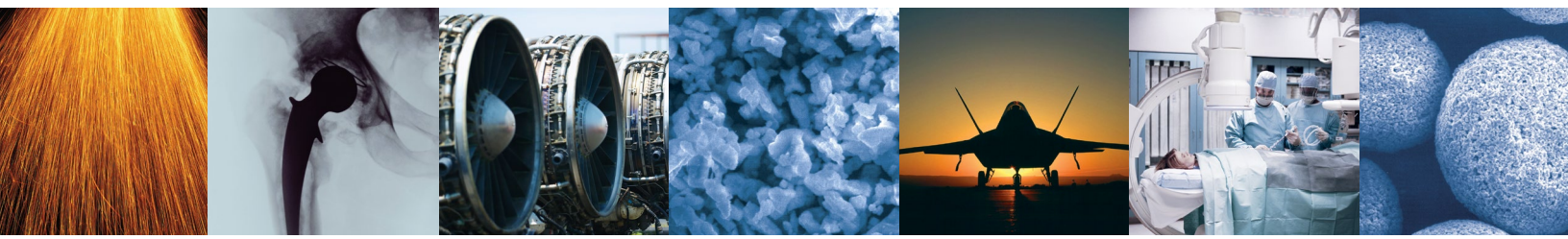

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