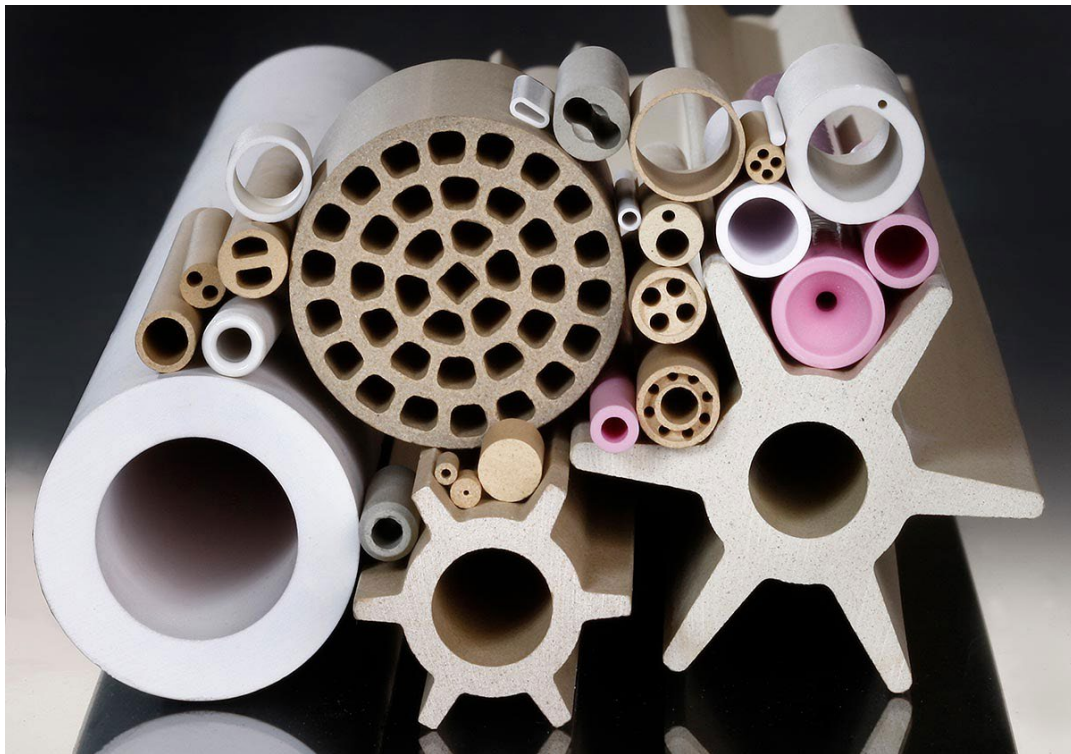


Advances in Technical Ceramics Made Possible By ResonantAcoustic[®] Mixing

Testimonials • Published Articles • Patents & Patent Applications



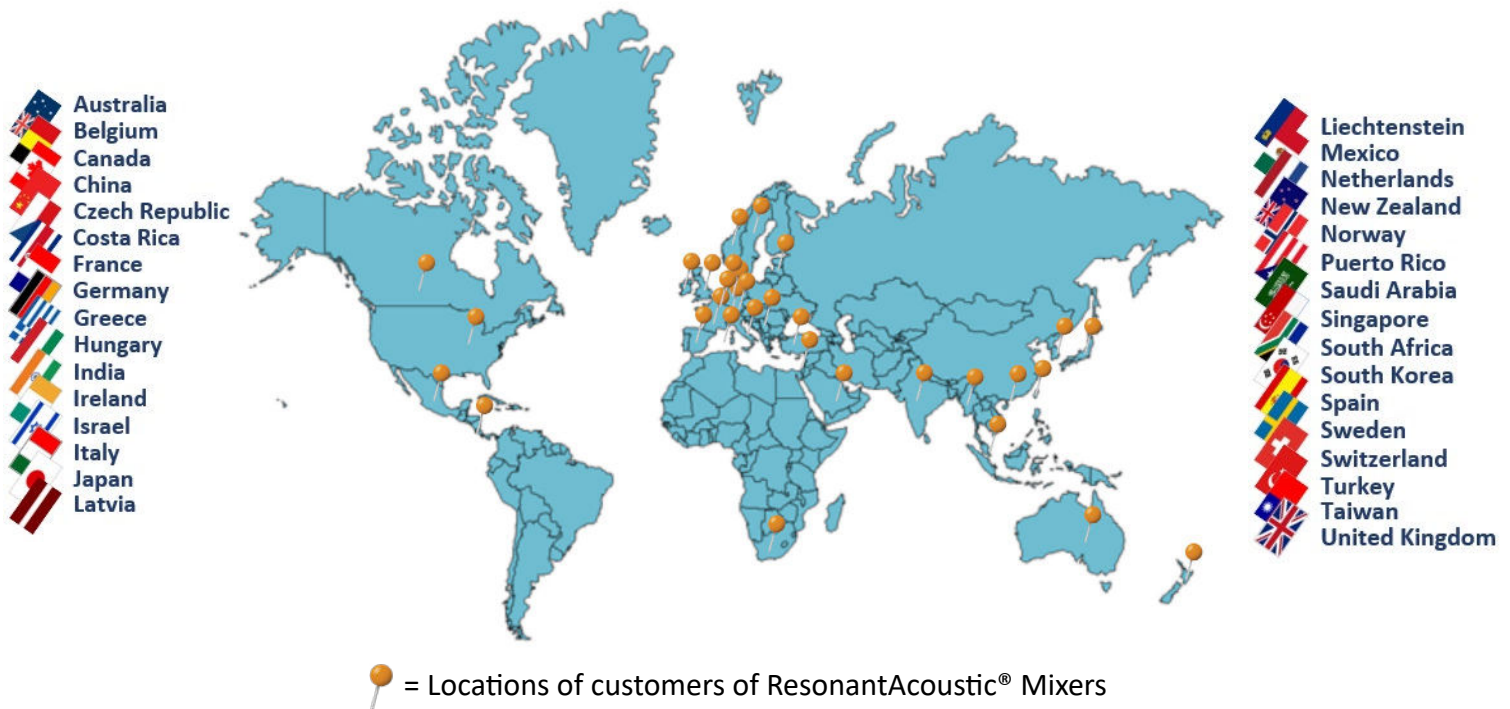
January 2022

This document is a portfolio of user testimonials, articles, and patents/patents pending that reference Resodyn's ResonantAcoustic[®] Mixing (RAM) technology in a variety of technical ceramics processing applications. This collection of abstracts and links to published articles is intended to provide insight into the value of RAM technology as a means of solving challenges, improving quality, and raising productivity in the development and processing of technical ceramics.

Processing of Technical Ceramics

Technical ceramics, also known as “high-performance” or “engineered” ceramics, are characterized by combinations of inorganic materials with physical and thermal properties that make them viable options for applications in which other materials (including conventional ceramics) aren’t feasible. Technical ceramics enable and create new opportunities for mechanical and plant engineering, foundries, automotive manufacturing, textile manufacturing, electronics, and medical technology applications.

Technical ceramics, aided by uniform, scalable mixing made possible by ResonantAcoustic® Mixing technology, enable profitable new applications and products across a wide spectrum of industries.



What organizations using technical ceramics say about RAM

“...Where RAM excels is at mixing pastes with high solids loading—that is, on the order of 80 percent solids and 20 percent liquid, or extremely viscous mixtures. We reduced mix times of highly viscous materials from five days to five minutes.”

- Research and Development Manager
U.S. Ceramic Products Manufacturer

“...Acoustic mixing opens up the possibility of adding oxides or ceramics to any metal, which creates a huge design space that wasn’t previously available.”









- Research Lab Scientist
U.S. Government Agency




RAM: 21st Century Mixing Technology for 21st Century Materials

More than a thousand RAM systems are in use in 33 countries around the world. RAM is the world’s preferred choice for innovation in materials processing.

PUBLISHED ARTICLES


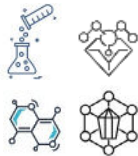


Icon Legend

	RAM testing, evaluation		Liquid/powder
	Material/chemical properties		Materials processing
	Powder/powder		Materials/product quality
	Ceramics		Nanomaterials

Icons	Publication Title (Live Links)*	RAM Application Summary	Year
	3D-printed nanoporous ceramics: Tunable feedstock for direct ink write and projection microstereolithography	“Ceramic inks for AM are of interest because of the advantages AM offers over traditional methods of ceramic forming...The 3YZ inks were made using solids loading in PEGDA ranging from 55 to 70 wt% (18–30 vol%, Table 2). The ink was mixed with spherical zirconia grinding beads (4 mm diameter) in an acoustic mixer (LabRAM II, Resodyn Acoustic Mixers, Butte, MT) for 3 h at 70 g-force to break up agglomerates and disperse the particles. The LabRAM II mixing time was determined by SEM images of the inks at different time points to ensure homogeneous dispersion.”	2021
	Investigation of the impact of particle size on properties and applications of a ceramic slurry	“... To make the ceramic slurry, 3YZrO2 nanoparticles were mixed with polyethylene glycol diacrylate (PEGDA Mn 575, Sigma Aldrich) and zirconia grinding media and mixed for 3 hours in a Resodyn™ LabRAM II acoustic mixer...”	2019
	Consolidation of Aluminum Magnesium Boride (AlMgB14) by Pulsed Electric Current Sintering (PECS) Technique	“Aluminum magnesium boride (AlMgBn) is a ternary ceramic alloy which retains unique physical and mechanical properties... this study examines pulsed electric current sintering (PECS) technique with a focus on establishing baseline processing parameters required to produce dense compacts with uniform microstructure. Subsequently, elemental powders of Al-12%Mg-74.7%B (wt%) were homogeneously mixed in a Resodyn resonant acoustic mixer and sintered using a PECS apparatus, at a temperature and pressure of 1600°C and 72.58 MPa. Formation of AlMg0.5B14 and minor phases of MgAl 2O4 and Mg0.78Al0.75B14 during sintering was confirmed. These studies led to the discovery of the ceramic alloy aluminum magnesium boride...”	2014

PUBLISHED ARTICLES

Cont'd.

Icons	Publication Title (Live Links)*	RAM Application Summary	Year
	Fabrication of high density pellets of ZrO₂ via particle processing	"...ResonantAcoustic [®] mixing demonstrated the ability to quickly mix powder blends that resulted in compact densities not much lower than the traditional processing route..."	2013
	Chemically bonded phosphate ceramics composites reinforced with graphite nanoplatelets	"...Chemically bonded phosphate ceramic (CBPCs) composites with 1.0 wt.% graphite nanoplatelets (GNPs) reinforcement have been manufactured. The GNPs were functionalized by different procedures, a nitric acid oxidation and a dried oxidation in open air...Results showed [ResonantAcoustic [®] Mixing (RAM)] was effective to remove most of the air bubbles and a homogeneous distribution of phases was observed with different microscopy techniques..."	2011
	Pultruded glass fiber-and pultruded carbon fiber-reinforced chemically bonded phosphate ceramics	"... [examines] the pultrusion process for glass fiber- and carbon fiber-reinforced chemically bonded phosphate ceramics (CBPCs). Samples were fabricated with 15% of fibers by volume. An improvement (with respect to the matrix) of 29 times for the bending strength of CBPCs pultruded graphite fibers composites and 17 times for CBPCs pultruded glass fiber composites is shown. Bending strength was obtained with the three-point bending test. The CBPCs were fabricated by mixing special formulations of both wollastonite powder and phosphoric acid, through ResonantAcoustic [®] mixing..."	2011
	Powder Processing and Properties Characterization of Polyamide 11-Graphene anocomposites for Selective Laser Sintering	"... Polymer nanocomposites of PA11 and nano-graphene platelets were mixed using powder mixing techniques. The Resodyn TM resonant acoustic mixer [was] used with the addition of zirconia grinding media to aid in the breaking and exfoliation of graphene clusters..."	2010

* Article links may be limited by copyright restrictions. Detailed links on following pages.

^ Results excerpted/paraphrased from articles.

Partial (edited) selection of searched technical articles using the following search terms (articles are live links): “resonant acoustic” “acoustic mixing” AND/OR: “Resodyn,” “technical ceramics”

[3D-printed nanoporous ceramics: Tunable feedstock for direct ink write and projection microstereolithography](#)

AL Troksa, HV Eshelman, S Chandrasekaran... - Materials & Design, 2021 - Elsevier

... Typically, ceramic inks for DIW are made from a highly viscous paste composed of ceramic... Ceramic AM can allow for creation of macroporous ceramics based on the geometry being ... order to create micro- or nanoporous ceramics, extra post-processing steps are necessary...

[Related articles](#)

[Investigation of the impact of particle size on properties and applications of a ceramic slurry](#)

HV Eshelman - 2019 - osti.gov

... Ceramic materials have a wide array of applications due to their desirable properties such as... ceramic slurry, 3YZrO₂ nanoparticles were mixed with polyethylene glycol diacrylate (PEGDA Mn 575, Sigma Aldrich) and zirconia grinding media and mixed for 3 hours in a Resodyn...

[Related articles](#)

[Consolidation of Aluminum Magnesium Boride \(AlMgB14\) by Pulsed Electric Current Sintering \(PECS\) Technique](#)

N Kedir, G Gilde, K Cho - Advances in Ceramic Armor IX, 2013 - Wiley Online Library

Aluminum magnesium boride (AlMgBn) is a ternary ceramic alloy which retains ... were homogeneously mixed in a resonant acoustic mixer and sintered using a PECS apparatus... Formation of AlMg_{0.5}B₁₄ and minor phases of MgAl₂O₄ and Mg_{0.78}Al_{0.75}B₁₄ during sintering was confirmed by X-ray diffraction (XRD) and energy dispersive X-ray spectroscopy (EDS) analysis.

[Related articles](#)

[Fabrication of high density pellets of ZrO₂ via particle processing](#)

TT Meek, J Yarringtonb - Journal of Ceramic Processing Research, 2013

...A low temperature-processing route that enables near net shapes in almost theoretical density is highly desirable. In order to carry out low-temperature processing, it is necessary to design oxide blends with controlled particle sizes. A compact made of the right mix of particles can be pressed at room temperature to near theoretical density. Powders have been blended to form multimodal distributions...

[Related articles](#)

[Chemically bonded phosphate ceramics composites reinforced with graphite nanoplatelets](#)

HA Colorado, C Hiel, HT Hahn - Composites Part A: Applied Science and ..., 2011 - Elsevier

... Two different mixing techniques were used, Thinky and Resonant Acoustic Mixing (RAM). Results showed both techniques are effective to ... Ceramics (CBPCs) materials as a potential substitution for ultra high strength cements and as an alternative ceramic based material for ...

[Related articles](#)

PUBLISHED ARTICLES

Cont'd.



Partial (edited) selection of searched technical articles using the following search terms (articles are live links): “resonant acoustic” “acoustic mixing” AND/OR: “Resodyn,” “technical ceramics”

Pultruded glass fiber-and pultruded carbon fiber-reinforced chemically bonded phosphate ceramics

HA Colorado, HT Hahn, C Hiel- Journal of composite ..., 2011- journals.sagepub.com

... for glass fiber- and carbon fiber-reinforced chemically bonded phosphate ceramics (CBPCs).

Samples were fabricated with 15% of fibers by ... were fabricated by mixing special formulations of both wollastonite powder and phosphoric acid, through resonant acoustic mixing. The ...

[Related articles](#)

Powder Processing and Properties Characterization of Polyamide 11-Graphene anocomposites for Selective Laser Sintering

DZ Chen, S Lao, JH Koo... - Proc. 2010 solid ..., 2010 - utw10945.utweb.utexas.edu

... Nanocomposites extend the paradigm of traditional composite materials by introducing fillers in the nano-scale to ceramic, metal, or ... Materials Preparation and Processing The Resodyn TM acoustic mixer (RAM) was the first method used to mix the PA11 and nano-graphene. ...

[Related articles](#)

Relevant Patents

Approved and pending applications for work involving the use of ResonantAcoustic[®] mixing technology.*

*Including patents with RAM as the preferred embodiment

Sintered polycrystalline cubic boron nitride material

WO EP US CN JP KR GB GB2560641A Can Antionette Element Six Uk Ltd

Priority 2017-03-15 • U.S. Filed 2018-03-13 • Published 2020-03-05 PCT / EP2018 / 056174

Abstract

A polycrystalline cubic boron nitride, PCBN, material is provided. The material comprises between 30 and 90 weight percent cubic boron nitride (cBN) and a matrix material in which the cBN particles are dispersed. The matrix material comprises particles of an aluminium compound; the matrix material particles having a d50 when measured using a linear intercept technique of no more than 100 nm.

Chemical-free production of graphene-reinforced inorganic matrix composites

WO US CN JP KR US10850496B2 Aruna Zhamu Global Graphene Group, Inc.

Priority 2016-02-09 • Filed 2016-02-09 • Granted 2020-12-01 • Published 2020-12-01

Abstract

Provided is a simple, fast, scalable, and environmentally benign method of producing a graphene-reinforced inorganic matrix composite directly from a graphitic material, the method comprising: (a) mixing multiple particles of a graphitic material and multiple particles of an inorganic solid carrier material to form a mixture in an impacting chamber of an energy impacting apparatus; (b) operating the energy impacting apparatus with a frequency and an intensity for a length of time sufficient for peeling off graphene sheets from the graphitic material and transferring the graphene sheets to surfaces of solid inorganic carrier material particles to produce graphene coated or graphene-embedded inorganic particles inside the impacting chamber; and (c) forming graphene-coated or graphene-embedded inorganic particles into the graphene-reinforced inorganic matrix composite. Also provided is a mass of the graphene-coated or graphene-embedded inorganic particles produced by this method.

By using resonance sound mixer to manufacture hard alloy or the method for metal ceramic powder

WO EP US CN JP KR ES CN103890204B

Priority 2011-10-17 • Filed 2012-10-17 • Granted 2016-11-16 • Published 2016-11-16

Abstract

The present invention relates to a kind of method manufacturing hard alloy or cermet body, including being initially formed the step of following powder blend, this powder blend comprises powder and the metal adhesive forming hard constituents. Then use non-contact type blender that described powder blend carries out married operation, wherein use the powder blend that the sound wave realizing resonance condition mixes with formation, and then the powder blend of described mixing is suppressed and sintering operation. Described method is able to maintain that the granularity of WC particle, particle size distribution and form.

Relevant Patents, cont'd.

[Chemical-free production of graphene reinforced inorganic matrix composites](#)

WO US CN JP KR JP2019506358A Nanotek Instruments, Inc.
Priority 2016-02-09 • Filed 2017-01-19 • Published 2019-03-07

Abstract

A simple, fast, scaleable and environmentally friendly method for producing graphene reinforced inorganic matrix composites directly from graphite materials: (a) a plurality of graphite materials in an impact chamber of an energy impact device (B) exfoliating the graphene sheet from the graphite material, and moving the graphene sheet to the surface of the solid inorganic carrier material particle. Operating the energy impingement device at a frequency and intensity for a time sufficient to form graphene-coated inorganic particles or graphene-embedded inorganic particles inside the collision chamber; and (c) graphene-coated inorganic particles or graphene Forming a graphene reinforced inorganic matrix composite from embedded inorganic particles It is subjected. A material for graphene-coated inorganic particles or graphene-embedded inorganic particles produced by this method is also provided.

[Method of powder coating and powder-coated fuser member](#)

US JP US8883264B2 Suxia Yang Xerox Corporation
Priority 2012-11-01 • Filed 2012-11-01 • Granted 2014-11-11 • Published 2014-11-11

Abstract

Methods for powder coating that include applying a powder coating composition to a substrate via an electrostatic gun. The powder coating composition includes a mixture of two or more materials having different densities, such as a mixture of aerogel particles and fluoropolymer-containing particles. The electrostatic gun can have a high-voltage generator that generates a negative polarity voltage between about 0 KV and about 100 KV during application of the powder coating composition, and the electrostatic gun can have a round spray nozzle. Methods of making fuser members using such powder coating methods, fuser members prepared by such methods, and methods of preparing low gloss images using such fuser members.

[Method for producing a cemented carbide or ceramic metal powder using a resonant acoustic mixer](#)

WO EP US CN JP KR ES ES2613643T3 Carl-Johans MADERUD Sandvik Intellectual Property Ab
Priority 2011-10-17 • Filed 2012-10-17 • Granted 2017-05-25 • Published 2017-05-25

Abstract

A method for producing a piece of cemented carbide or ceramic metal, comprising the steps of: forming a powder mixture comprising powders that form hard constituents and metallic binder;- subjecting said powder mixture to a mixing operation using a resonant non-contact acoustic mixer where acoustic waves are used that have a frequency that achieves resonance conditions to form a combination of mixed powders, where the frequency used is between-80 Hz,- subjecting said combination of mixed powders to a forming and sintering operation.



RAM 5 Continuous



RAM 55



OmniRAM Continuous



RAM 5



RAM 5H



OmniRAM



LabRAM I



LabRAM II H

LabRAM II

