Jožef Stefan Institute (JSI)
Ljubljana, Slovenia

Instituto de Ciencia de Materiales de Madrid
Consejo Superior de Investigaciones Científicas

ALUMINA and ZIRCONIA CERAMICS

Nano cellulose-reinforced alumina and zirconia ceramics with improved microstructural, mechanical and electro-conducting properties

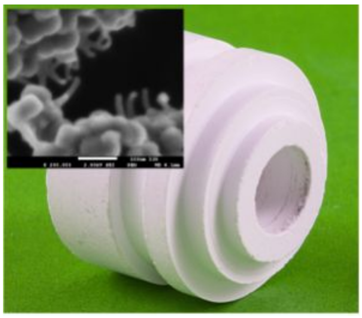
New nano filler:

- **nano-particulated cellulose:**

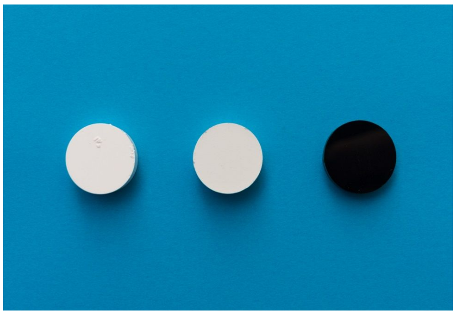
-> sustainable, natural, hydrophilic, insoluble, homogeneously distributed

Optimized preparation to new filler:
matrix -> greenbody -> machining -> sintering
(-> electro-discharge machining)

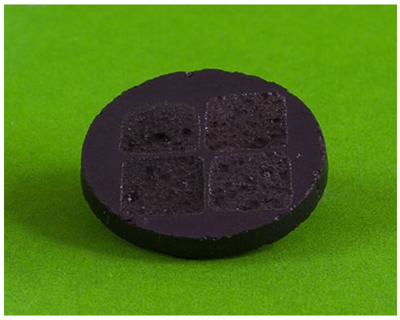
Suitable for automotive and biomedical applications where electro-conductive (bio)inert engineering ceramics are desired



Improved microstructural and mechanical properties strength (Hv=20 GPa) allow complex shaped machining prior to sintering. Incorporated nanocellulose filler in form of fibres can be seen on the SEM image (top left corner).



Nanocellulose-zirconia before (left) and after (right) SPS sintering. It turns black due to *in situ* graphitization of the nanocellulose. The black sample is highly electroconductive (400 S/m).



Electro-discharge machined (EDM) nanocellulose-alumina. EDM in the sintered phase is possible due to percolation threshold achieved at lowered carbon content.

IPR status: *Patent applied but not yet granted*
Development stage: *Tested in the research pilot production system resembling existing industrial ceramics production lines.*
Partners sought: Producers of alumina and zirconia ceramic articles willing to implement the technology into their production line under license and technical cooperation agreement

Please find more details on the offer in Appendix

It all started during the course of scientific collaboration between JSI and CSIC on fire retardant foams ***recently published in Nature (click here)****. The knowledge in ceramics development (JSI) and the knowledge on nano-cellulose based hybrid and composite materials (CSIC) were integrated and the idea of adding hydrophilic nano-cellulose filler rather than conventional hydrophobic carbon fillers to ceramic matrix was born.*

ACCESS KNOWLEDGE, STAFF AND LABORATORIES THROUGH

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Technology Offer

Nano cellulose reinforced alumina and zirconia ceramic composites with improved mechanical and electrically conductive properties

Summary

A Slovenian and a Spanish research organization have developed a new type of alumina and zirconia ceramics with improved mechanical and electrically conductive properties achieved by nano-particulated cellulose filler. Complex shaped machining as well as electro-discharge machining is possible due to improved properties. Producers of ceramics, especially for automotive and biomedical applications are sought for licensing and technical cooperation.

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Last Update	12 May 2017
Expiration Date	12 May 2018
Reference	TOSI20170414001
Profile link	http://een.ec.europa.eu/tools/services/PRO/Profile/Detail/97f32ce2-b222-4f95-863a-c66d5be6b1c1

Details

Description

Products of alumina and zirconia ceramics such as molds, resistors, electrodes, heating elements, resonators etc. are not only designed to operate in harsh environments but also produced in harsh environments undergoing complex shaping or non-conventional shaping techniques (e.g. electro discharge machining or green body machining). Therefore the capability of these materials to resist high levels of electric and mechanical stress is crucial.

During the course of scientific collaboration on fire retardant foams Slovenian and Spanish research organizations invented new formulation for carbon fibre reinforced and electrically conductive alumina and zirconia ceramics.
The core of invention is insoluble cellulose nanoparticulated material added as a filler to aqueous ceramic suspension followed by optimized steps of drying, green body formation and sintering to form reinforced electrically conductive ceramic article. This filler is - unlike hydrophobic carbon fillers (e.g. carbon nanotubes or carbon black allows) that are already on the market – composed of natural insoluble but hydrophylic nanoparticles (nanofibres and nanorods) of cellulose that are mixed into the aqueous solution of ceramic particles and consolidate their matrix.
The insolubility and nano-size of these hydrophilic nano-cellulose particles enable their homogeneous distribution across the ceramic matrix which is then dried and pressed into the green body preserving the homogeneous distribution of cellulose and ceramic nano-particles across the material. This homogeneous distribution enables the filler to be added at smaller quantities making the green body stronger and more resistant to machining as compared to green bodies reinforced with more concentrated and/or soluble and/or differently sized and/or

less equally distributed fillers available on the market.
High electrical conductivity is established during the sintering of machined green body upon which the cellulose nanofibres convert to carbon fibres. The equal distribution and low concentration of conducting carbon fibres is again preserving the valuable mechanical properties of ceramics made by the procedure described above.

The idea of adding hydrophilic nano-cellulose filler rather than conventional hydrophobic carbon fillers to ceramic matrix was a result of integration of knowledge on ceramics development and nano-cellulose based hybrid and composite materials integrated from Slovenian and Spanish research organizations, respectively.

A patent application with more detailed description of the filler and the procedure of production of these ceramics was filed.
Researchers are looking for producers of alumina and zirconia ceramics, especially electrically conductive and (bio)inert engineering ceramics for automotive and biomedical applications. They wish to license out the technology.
Technical cooperation is also offered in the form of facilities and the know-how of involved research institutes and researchers on how to implement the technology with slight modifications to existing industrial production scales of the companies interested in licensing in the presented technology.

Advantages and Innovations

Improved mechanical properties (Hv=20 GPa) allow complex shaped machining prior to sintering (Figure 1 attached);

High electrical conductivity (400 S/m) is achieved at extremely low percolation thresholds due to nanosized filler that is equally distributed across the material. Electrical conductivity is triggered during sintering upon which the nano-cellulose filler is turned to conductive carbon fibres (Figure 2 attached);

Electro-discharge machining (EDM) is also possible due to favourable electrically conductive properties of the material (Figure 3 attached).

Stage of Development

Prototype available for demonstration

Comments Regarding Stage of Development

The method of preparation of nano-cellulose reinforced ceramics was tested in the research pilot production system resembling existing industrial ceramics production lines. The technology needs to be validated, demonstrated and qualified at industrial scale in a course of proposed collaboration between the research organizations and interested industrial partners.

IPR Status

Patent(s) applied for but not yet granted

Comment Regarding IPR status

Patent application was filed in November 2016 at UK-IPO. In addition to intellectual property rights described in the patent application the inventors and institutions involved own specific knowledge and practical experiences (secret know-how) on how to implement the technology with slight modifications of existing industrial production scales.

Profile Origin

National or Regional R&D programme

Keywords

Technology

01002007	Nanotechnologies related to electronics & microelectronics
02002010	Machining (turning, drilling, moulding, planing, cutting)
02002011	Machining, fine (grinding, lapping)
02007003	Ceramic Materials and Powders
02007005	Composite materials

Market

01005004	Microwave and satellite components
03001001	Semiconductors
08001013	Ceramics
08004002	Chemical and solid material recycling
09003001	Engineering services

NACE

M.72.1.9	Other research and experimental development on natural sciences and engineering

Network Contact

Issuing Partner
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Open for EOI : Yes

Dissemination

Send to Sector Group
Materials

Client

Type and Size of Organisation Behind the Profile

R&D Institution

Year Established

1946

Turnover

<1M

Already Engaged in Trans-National Cooperation

Yes

Languages Spoken

English
Slovenian

Client Country

Slovenia

Partner Sought

Type and Role of Partner Sought

The technology is ready to be licensed out to interested producers of alumina and zirconia ceramics, especially electrically conductive and (bio)inert engineering ceramics for automotive and biomedical applications. Technical cooperation is also offered, more precisely the facilities and the knowledge of Slovenian and Spanish research institutes and researchers on how to implement the technology with slight modifications to existing industrial production scales of the companies interested in licensing in the presented technology.

Type and Size of Partner Sought

SME 11-50,SME <10,>500 MNE,251-500,SME 51-250,>500

Type of Partnership Considered

License agreement
Technical cooperation agreement

Attachments

Fig1.jpg

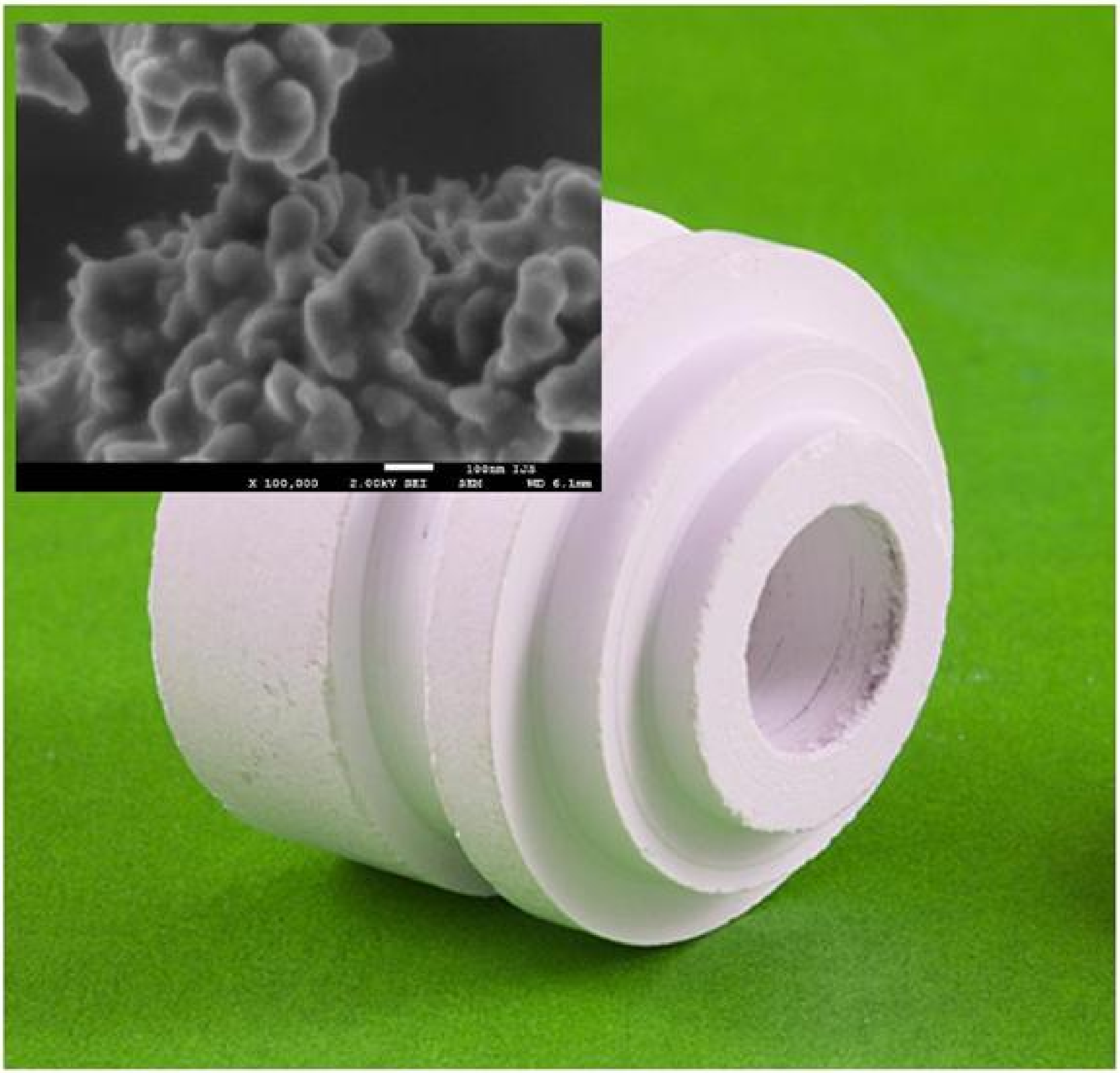

Figure 1. Photograph of a machined greenbody (non-sintered) of nanocellulose-zirconia nanocomposite. High strength (Hv=20 GPa) and improved mechanical properties of the ceramic greenbody allowing to machine complex geometries prior to sintering – due to incorporated nanocellulose inferring high mechanical properties (see the SEM - scanning electron microscope - image in the top left corner).

Fig3.jpg

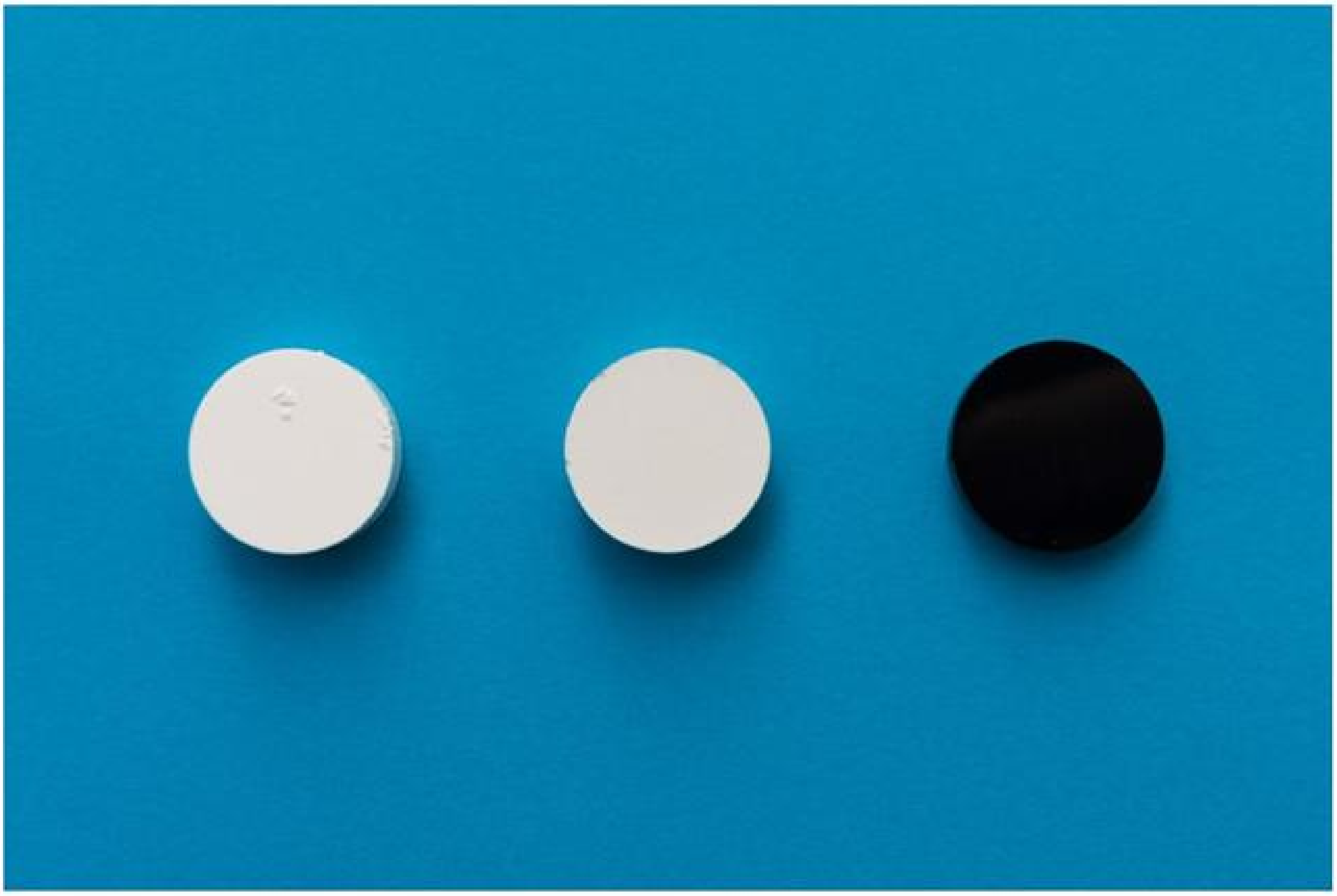

Figure 2. Photograph of nanocellulose-zirconia before (left) and after (right) SPS – spark plasma sintering. After sintering it turns black due to graphitization of the nanocellulose. The black sample is highly electroconductive (400 S/m).

Figure 3. Photograph of nanocellulose-alumina after electro-discharge machining (EDM), which is posible due to the electroconductivity of the sample. EDM is an advanced ceramic machining technique.

Fig2.jpg