Technology Summary: 3Y-TZP Ceramic Material with Enhanced Strength and Fracture Toughness

Opportunity Statement

The global advanced ceramic market is enjoying rapid growth and is expected to reach US$56.4 billion by 2015. In the US alone, the market is projected to grow 6.2 per cent annually between 2009 and 2014 to $12.2 billion. This growth is expected to accelerate as advanced ceramics penetrate new applications where they are valued for their favorable performance.

Zirconia has the highest strength and toughness at room temperature of all the advanced ceramic materials. This material exhibits an important feature known as transformation toughening, which can prevent growth of cracks, resulting in a material with high mechanical strength. Zirconia used in demanding environments is usually a tetragonal polycrystalline zirconia, partially stabilized with about 3 mol% yYttria (3Y-TZP).

Due to its high mechanical strength, thermal resistance, corrosion resistance and non-magnetic properties, 3Y-TZP has found applications in a wide range of products including dental implants, bioceramics, cutting tools and even casings for watches.

Problem

Ceramics are brittle by nature and are sensitive to stress concentrations around pre-existing small defects such as pores or cracks. Increasing the fracture toughness of 3Y-TZP can allow the material to withstand higher stress and enhance its reliability and utility. Conventional methods to improve fracture toughness include fiber toughening, particle toughening and piezoelectric secondary phase toughening. **None of the abovementioned methods are able to increase simultaneously both fracture toughness and strength.**

Therefore, there is a need for a technology that can enable high fracture toughness and strength in 3Y-TZP materials to meet the requirements for more demanding applications such as impact-resistant structures .

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360ip Partner's Solution

The 360ip Partner's invention employs simultaneous silicon carbide (SiC) whisker reinforcement and $Sr_2Nb_2O_7$ piezoelectric secondary phase toughening to produce a composite ceramic with enhanced fracture toughness and strength.

The technology involves the following process steps:

1. Preparation of 3Y-TZP, SiC whisker and $Sr_2Nb_2O_7$ mixture

1.1 Prepare $Sr_2Nb_2O_7$ powder by mixing $SrCO_3$ and Nb_2O_5, milling, drying and calcination.

1.2. Prepare mixture of 3Y-TZP, SiC whisker, and $Sr_2Nb_2O_7$ according to required ratio.

2. Ball Milling

2.1. Ball mill the mixture with anhydrous ethanol medium for 10-20 hours.

2.2. Dry resulting slurry and filter.

3. Forming

3.1. Add 2-4% polyvinyl alcohol as binder into powder from step 2 and press at 20-40Mpa.

3.2. Heat sample to degum.

4. Sintering

4.1. Sinter degummed sample in microwave sintering furnace at a temperature of 1400 to 1600 °C for 10 to 30 minutes.

Compared to existing methods, 3Y-TZP prepared according to the invention has the following advantages:

- High fracture toughness (18-25 $MPam^{1/2}$)
- High strength (1600 -1800 MPa)
- Simple preparation process
- Shortened sintering time

Patents

360ip's Partner has filed one patent application on this technology and plans to seek protection in multiple jurisdictions.

360ip is seeking interested parties for the licensing, further development and commercialization of this technology-based product.

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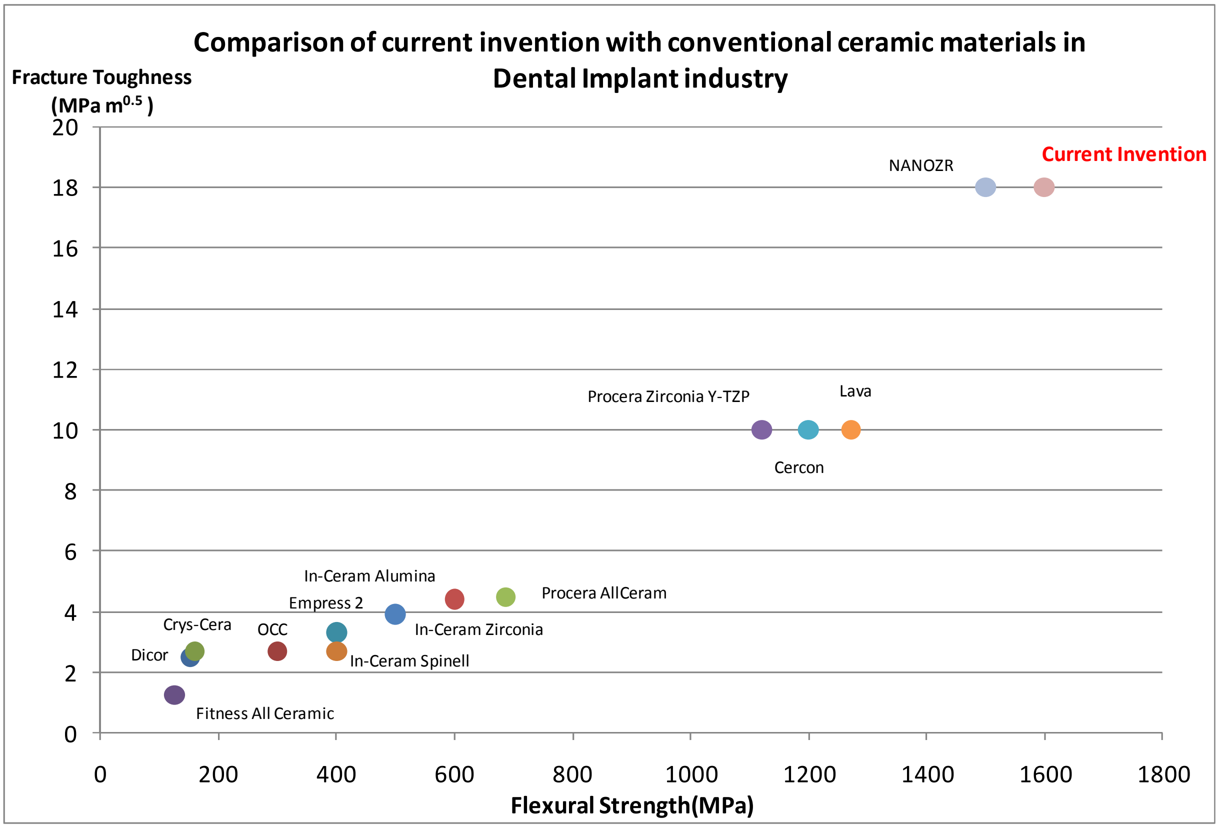

Note: Data taken from the paper "Reliability and properties of core materials for all-ceramic dental restorations", Seiji Ban, Japanese Dental Science Review, Volume 44, Issue 1, July 2008, Pages 3-21

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