Preparation, Properties and Application of Nano Glass Ceramics

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ABSTRACT

Glass ceramics are a special group of materials in which base glass can be crystallized under carefully controlled conditions. Which in determine the properties of the material. Bio active glass ceramics material has the interfacial interaction with surrounding tissue. Glass ceramic thin films were prepared from the different composition of the materials (CaO-SiO₂·P₂O₅–CaF₂-MgO). The different concentration of 50 g, 100 g, 150 g, and 200 g glass ceramics was examined by sintering technique. The different Properties and good bio compatibility make it useful in artificial bone and dental implants.

Keywords: glass ceramics, artificial bone, Bio active materials.

1. INTRODUCTION

A wide range of materials is used in the construction of medical devices and each material will interact in some way with the biological environment. The class of ceramics used for repair and replacement of diseased and damaged parts of musculoskeletal systems are termed bio ceramics. Glass ceramics range in biocompatibility from the ceramic oxides, which are inert in the body, to the other extreme of resorbable materials by which are eventually replaced by the materials which they are used to repair. Bio ceramics are now used in a number of different applications throughout the body. They are usually used to replace hard tissue in the body like bone and teeth. The challenge for the materials scientists is to develop new...
ceramics that produce the most appropriate response that the clinical situation demands. It has been accepted that no foreign material placed within a living body is completely compatible. The only substances that conform completely are those manufactured by the body itself. No synthetic material can be considered as being inert as all materials will produce some sort of a response from living tissue. These materials will be recognized as foreign and may initiate any of a range of tissue responses. In general, bio ceramics can be classified according to their tissue response as being bio inert, bioactive, or resorbable ceramics.

The glass ceramic has superior mechanical properties, good biocompatibility, bio activity and no toxicity making it useful as a bio material in artificial bone and dental implants. This good mechanical property makes this glass ceramic potentially suitable for such applications as load bearing implants. In the present work, we first utilized the preparation of nano formed glass ceramics using thin film techniques and their mechanical properties, applications are also discussed.

2. EXPERIMENTAL DETAILS

A nano sized thin film glass ceramic materials were prepared on well cleaned glass substrate by sintering method at 750°C. The goal of the sintering process is to convert highly porous compacted powder into high strength bodies. During sintering, the significant strengthening of the ceramic body is due to the formation of inter-particle resulting from atomic motion at the sintering temperature. A/W (apatite/wollastonite) glass ceramics contains different combination of CaO-SiO2-P2O5-MgO-CaF2 materials. Appropriate amount of solvent was added to distilled water one by one slowly. The physically mixed solution was coated on the mechanical behaviour was studied by preparing a rod. The rod was prepared by injecting prepared solution into plastic tube. The metal cylindrical / rectangular shape was heated at 900°C, and then the rod was cooled to room temperature gradually. The desired size was taken out carefully. The different composition (25g, 50g) of the A/W glass ceramic rod was done by different composition of the material was noted in table 1.

Table 1. Materials and composition

<table>
<thead>
<tr>
<th>Material (A/W glass ceramic)</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>12 23.5</td>
</tr>
<tr>
<td>SiO2</td>
<td>9 19</td>
</tr>
<tr>
<td>P2O5</td>
<td>1.5 3</td>
</tr>
<tr>
<td>CaF2</td>
<td>0.5 0.5</td>
</tr>
<tr>
<td>MgO</td>
<td>2 4</td>
</tr>
</tbody>
</table>

2.1. MATERIAL CHARACTERISTICS

One of the most important modifications of bioactive glasses was the development of A/W (apatite/wollastonite) bioactive glass-ceramics by Yamamuro and Kokubo, et al. Kyoto University, Kyoto, Japan. A unique processing method produced a very fine-grained glass ceramic composed of very small apatite (A) and wollastonite (W = CaSiO3) crystals bonded by a bioactive glass interface. Mechanical strength, toughness, and stability of AW glass-ceramics (AW-GC) in physiological environments are excellent. Bone was found to bond to A/W-GC.
implants with a high interfacial bond strength. An apatite–wollastonite glass ceramic can be produced in the SiO$_2$–CaO–MgO–P$_2$O$_5$–F system. The chemical composition in wt% comprises 34.0 SiO$_2$, 44.7 CaO, 4.6MgO, 16.2 P$_2$O$_5$, and 0.5 CaF$_2$. One problem with A/W glass ceramics is that wollastonite tends to surface nucleate, such that it cannot be cast into a glass block and then crystallized. However, it can be made into a glass-ceramic by putting the glass powder through a firing cycle that combines densification with crystallization. We examined the glass ceramic rods with 97-97.25 G Pa young’s modulus was obtained and it also very close to the reported values.

3 RESULTS AND DISCUSSION

3.1 XRD Analysis

![X-ray diffractogram A/W glass ceramic thin film by sintering method](image)

The structural analysis of A/W glass ceramic thin films was carried out by using X-ray diffractometer. The X-ray diffraction patterns of the A/W glass ceramic thin films, grown on glass substrates are shown in Figure 1. The XRD analysis shows that the thin films are polycrystalline nature with cubic phase with 396 nm film, indicating that the grain size in this film is larger. The peak at $2\theta = 16.51^\circ$ is stronger than other peaks. The grain size was found to be about 20 nm for the crystallites grown in this direction, or the average radius of the crystallites is about 10 nm. It is necessary to remind by the fact that, lines of smaller intensity give smaller values of $d$. The crystallite size in A/W glass ceramic thin film is evaluated from the intensity peaks of XRD by a Gaussian fit, using Debye-Scherrer formula$^{10}$,

$$D = \frac{0.98 \lambda}{\beta \cos \theta}$$

Where, $\beta$ is the Full width at half maximum, $\lambda$ is the wavelength of X-ray used and $\theta$ is the Bragg’s angle. The lattice parameters, ‘a’ and ‘c’ of the unit cell and strain, dislocations were calculated by using the classical relations$^{11-13}$.

3.2 Morphological analysis

Fig.2 (a-b) shows the scanning electron microscope (SEM) image of A/W glass ceramics. A/W glass ceramics coated to well clean glass plates by sintering method. Fig.2 gives material bonding with the other materials. Almost particles were distributed throughout the substrate. The particles are enlarged at up to 500 nm range. The density of the material is closely packed together with some bridging defects was present at SEM image. In this process sintering was performed at 750°C. The defects were overcome by increasing the temperature up to 900°C. SEM image representing the glass ceramics film formation with cluster of grains forming a big particle bonding with other particle of size varying 500 nm to 2000 nm.
4. CONCLUSIONS

One of the most important modifications of A/W (apatite/wollastonite) bio-active glass-ceramic thin films was prepared by sintering technique. X-ray analysis of A/W glass ceramic was polycrystalline in nature with cubic phase. The average grain size of these materials gives as to A/W Glass Ceramics in orthopaedic Application Scanning electron microscope image of A/W Glass ceramic the materials are closely packed together. The Young’s Modulus values of A/W glass ceramic was measured by cantilever method. The observed value was (97-97.25Gpa) nearly matched with standard value. The A–W glass ceramic is also machinable but its major drawback is the relatively. Low fracture toughness compared with other ceramics such as alumina or Zirconia. Unfortunately, despite having a superior mechanical strength too many other biomaterials such as bioactive glasses, bio ceramics, and bone, A–W glass ceramic cannot be used to repair bone defect in high stress bearing areas such as the femur or tibial bones, as its fracture toughness is too low and its elastic modulus too high. This good mechanical property makes this glass ceramic potentially suitable for such applications as load bearing implants.

REFERENCES