masking membrane to cover a bone defect. The guided bone regeneration technique does not involve charging a material into the affected area. Instead, this techniques uses a masking membrane, which has the functions of preventing the invasion of cells and tissues not involved in bone formation into the bone defect, allowing the self-regeneration ability of the bone to exhibit, and helping the bone to reconstruct. This technique is intended to cure the bone defect by using the curing ability that a living body inherently has. For example, Japanese Unexamined Patent Application Publication (JP-A) No. 2009-61109 discloses a guided bone regeneration membrane and a production method thereof, wherein guided bone regeneration membrane has a bi-layer structure including a first nonwoven fabric layer and a second nonwoven fabric layer, in which the first nonwoven fabric layer contains a silicon-releasable calcium carbonate and a biodegradable resin as principal components, and the second nonwoven fabric layer contains a biodegradable resin as a principal component. It has been reported that the use of this membrane gives satisfactory proliferation of murine osteoblast-like cells (MC3T3-E1 cells), and when a bone defect formed in a rabbit cranial bone is covered by such a membrane, satisfactory bone formation (osteogenesis) is observed (*see* T. Wakita, A. Obata and T. Kasuga, "*New Fabrication Process of Layered Membranes Based on Poly (Lactic Acid) Fibers for Guided Bone Regeneration*", Materials Transactions, 50 [7], 1737-1741 (2009)). This membrane, however, is not usable as a material for filling bone defects because it has a small thickness of from 230 to 300μm. In addition, the bulk density of such membranes, estimated to be about 0.4 g/cm^3 or more, is generally too high to be used as a material for filling bone defects.

SUMMARY ~~OF THE INVENTION~~

[0010] Accordingly, an object of the present ~~invention~~disclosure is to provide a fiber wadding formed of a bioresorbable material for filling bone defects, which material may have a sustained release system with such a chemical composition as to guide bone reconstruction ability effectively and has a three-dimensional structure having such a flexibility as to fit in an affected area satisfactorily.

[0011] In one ~~aspect~~embodiment, the present ~~invention~~disclosure relates to a fiber wadding for filling bone defects, wherein the fiber wadding having a flocculent three-dimensional structure including a plurality of

fibers. The fibers contain a biodegradable resin as a principal component and contain or bear a siloxane.

[0011a] In one aspect, there is provided a fiber wadding for filling bone defects having a flocculent three dimensional structure, the fiber wadding comprising biodegradable fibers produced by using an electrospinning apparatus having multiple nozzles and a charged collector filled with ethanol,

wherein the biodegradable fibers comprise a biodegradable resin and silicon-releasable calcium carbonate micro-particles,

wherein outside diameter of the biodegradable fibers is from about 0.05 μm to about 30 μm; and

wherein a bulk density of the fiber wadding, as measured in accordance with JIS L 1097, is from about 0.01 g/cm^3 to about 0.1 g/cm^3.

[0012] In one ~~aspect~~embodiment, fibers in a fiber wadding of the ~~invention~~disclosure may be coated with hydroxyapatite on their surfaces. The biodegradable resin may be poly(lactic acid) or a copolymer thereof. The fibers may contain siloxane dispersed in calcium carbonate micro-particles.

[0013] In one ~~aspect~~embodiment, the present ~~invention~~disclosure relates a fiber wadding for filling bone defects comprising a plurality of fibers comprising a biodegradable resin and vaterite phase calcium carbonate micro-particles, wherein the plurality of fibers are entangled with each other in three dimensional directions to form a fiber wadding such that a bulk density of the fiber wadding is 0.005 – 0.3 g/cm^3.

[0014] In one ~~aspect~~embodiment, the present ~~invention~~disclosure relates to a fiber wadding for filling bone defects comprising a plurality of biodegradable fibers containing a plurality of calcium carbonate micro-particles and siloxane. The biodegradable fibers are three-dimensionally entangled each other to create three-dimensional spaces of about several tens of micrometers or more throughout the fiber wadding structure such that the fiber wadding has a sufficient flexibility in all three-dimensional directions thereof without forming a flat mat structure. Bulk density of the fiber wadding as measured in accordance with JIS L 1097 is from about 0.005 g/cm^3 to about 0.3 g/cm^3.

[0015] In one ~~aspect~~embodiment, the present ~~invention~~disclosure relates to a fiber wadding for filling bone defects comprising a plurality of fibers that contain a biodegradable resin, vaterite phase calcium carbonate micro-particles and siloxane. The plurality of fibers are entangled each other in three dimensional directions to form a fiber wadding structure such that the fiber wadding has substantially a same flexibility in all three-dimensional directions thereof. A bulk density of the fiber wadding is about 0.005 g/cm^3-0.3 g/cm^3, compressibility of the fiber wadding as measured in accordance with JIS L 1097 is from about 10% to about 55%, and compression recovery of the fiber wadding as measured in accordance with JIS L 1097 is from about 5% to about 76%.

[0015a] In another aspect, there is provided a fiber wadding for filling bone defects, comprising biodegradable fibers produced by using an electrospinning apparatus having multiple nozzles and a charged collector filled with ethanol,

wherein the biodegradable fibers comprise a biodegradable resin, vaterite phase calcium carbonate micro-particles, a siloxane dispersed in the micro-particles, and a calcium phosphate,

wherein outside diameter of the biodegradable fibers is from about 0.05 μm to about 30 μm; and

wherein the biodegradable fibers are entangled each other in three dimensional directions to form a flocculent three dimensional structure such that the fiber wadding has a bulk density of 0.01 g/cm^3 to about 0.1 g/cm^3, compressibility of about 10-55%, compression recovery of about 5-76% as measured in accordance with JIS L 1097.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Other objects, features and advantages of the present invention will be understood more

CLAIMS

WHAT IS CLAIMED IS:

1. A fiber wadding for filling bone defects comprising a plurality of biodegradable fibers containing a plurality of calcium carbonate micro-particles and siloxane,

   wherein the biodegradable fibers are three-dimensionally entangled each other to create three-dimensional spaces of about several tens of micrometers or more throughout the fiber wadding structure such that the fiber wadding has a sufficient flexibility in all three-dimensional directions thereof, and

   wherein bulk density of the fiber wadding as measured in accordance with JIS L 1097 is from about 0.005 g/cm^3 to about 0.3 g/cm^3.

2. The fiber wadding according to claim 1, wherein outside diameter of the plurality of biodegradable fibers is from about 0.05 um to about 30 um.

3. The fiber wadding according to any one of claims 1 and 2, wherein bulk density of the fiber wadding as measured in accordance with JIS L 1097 is from about 0.01 g/cm^3 to about 0.1 g/cm^3.

4. The fiber wadding according to claim 1 and 2, wherein bulk density of the fiber wadding as measured in accordance with JIS L 1097 is from about 0.014 g/cm^3 to about 0.021 g/cm^3.

5. The fiber wadding according to any one of claims 1-4, wherein compressibility of the fiber wadding as measured in accordance with JIS L 1097 is from about 10% to about 55%.

6. The fiber wadding according to any one of claims 1-4, wherein compressibility of the fiber wadding as measured in accordance with JIS L 1097 is from about 20% to about 55%.

7. The fiber wadding according to any one of claims 1-4, wherein compressibility of the fiber wadding as measured in accordance with JIS L 1097 is from about 29% to about 55%.

8. The fiber wadding according to any one of claims 1-7, wherein compression recovery of the fiber wadding as measured in accordance with JIS L 1097 is from about 5% to about 76%.

9. The fiber wadding according to any one of claims 1-7, wherein compression recovery of the fiber wadding as measured in accordance with JIS L 1097 is from about 7% to about 76%.

10. The fiber wadding according to any one of claims 1-7, wherein compression recovery of the fiber wadding as measured in accordance with JIS L 1097 is from about 44% to about 58%.

11. The fiber wadding according to any one of claims 1-10, wherein the biodegradable fibers comprises poly(lactic

acid) or a copolymer thereof.

12. The fiber wadding according to any one of claims 1-11, wherein the plurality of fibers are coated with hydroxyapatite.

13. A fiber wadding for filling bone defects comprising a plurality of fibers that contain a biodegradable resin, vaterite phase calcium carbonate micro-particles and siloxane,

wherein the plurality of fibers are entangled each other in three dimensional directions to form a fiber wadding structure such that the fiber wadding has substantially a same flexibility in all three-dimensional directions thereof, and

wherein a bulk density of the fiber wadding is about 0.005 g/cm^3-0.3 g/cm^3 , compressibility of the fiber wadding as measured in accordance with JIS L 1097 is from about 10% to about 55%, and compression recovery of the fiber wadding as measured in accordance with JIS L 1097 is from about 5% to about 76%.

14. The fiber wadding according to claim 13, wherein outside diameter of the plurality of fibers is from about 0.05um to about 30um.

15. The fiber wadding according to any one of claims 13 and 14, wherein outside diameter of the plurality of fibers is from about 0.1um to about 20um.

16. The fiber wadding according to any one of claims 13-15, wherein bulk density of the fiber wadding as measured in accordance with JIS L 1097 is from about 0.01um to about 0.1 g/cm^3.

17. The fiber wadding according to any one of claims 13-16, wherein the plurality of fibers are coated with hydroxyapatite.

18. The fiber wadding according to any one of claims 13-17, wherein the biodegradable resin is poly(lactic acid) or a copolymer thereof.

19. The fiber wadding according to any one of claims 13-18, wherein the plurality of fibers contain siloxane dispersed in the vaterite phase calcium carbonate micro-particles.

CLAIMS

WHAT IS CLAIMED IS:

1. A fiber wadding for filling bone defects having a flocculent three dimensional structure, the fiber wadding comprising biodegradable fibers produced by using an electrospinning apparatus having multiple nozzles and a charged collector filled with ethanol,

wherein the biodegradable fibers comprise a biodegradable resin and silicon-releasable calcium carbonate micro-particles,

wherein outside diameter of the biodegradable fibers is from about 0.05 μm to about 30 μm; and

wherein a bulk density of the fiber wadding, as measured in accordance with JIS L 1097, is from about 0.01 g/cm^3 to about 0.1 g/cm^3.

2. The fiber wadding according to claim 1, wherein the biodegradable fibers further comprise calcium phosphate.

3. The fiber wadding according to claim 1, wherein the biodegradable resin comprises poly(lactic acid) or a copolymer thereof.

4. The fiber wadding according to claim 1, wherein compressibility of the fiber wadding as measured in accordance with JIS L 1097 is from about 10% to about 55%.

5. The fiber wadding according to claim 1, wherein compressibility of the fiber wadding as measured in accordance with JIS L 1097 is from about 20% to about 55%.

6. The fiber wadding according to claim 1, wherein compressibility of the fiber wadding as measured in accordance with HS L 1097 is from about 29% to about 55%.

7. The fiber wadding according to claim 1, wherein compression recovery of the fiber wadding as measured in accordance with JIS L 1097 is from about 5% to about 76%.

8. The fiber wadding according to claim 1, wherein compression recovery of the fiber wadding as measured in accordance with JIS L 1097 is from about 7% to about 76%.

9. The fiber wadding according to claim 1, wherein compression recovery of the fiber wadding as measured in accordance with JIS L 1097 is from about 44% to about 58%.

10. A fiber wadding for filling bone defects, comprising biodegradable fibers produced by using an electrospinning apparatus having multiple nozzles and a charged collector filled with ethanol,

wherein the biodegradable fibers comprise a biodegradable resin, vaterite phase calcium carbonate micro-particles, a siloxane dispersed in the micro-particles, and a calcium phosphate,

wherein outside diameter of the biodegradable fibers is from about 0.05 μm to about 30 μm; and

wherein the biodegradable fibers are entangled each other in three dimensional directions to form a flocculent three dimensional structure such that the fiber wadding has a bulk density of 0.01 g/cm^3 to about 0.1 g/cm^3, compressibility of about 10-55%, compression recovery of about 5-76% as measured in accordance with JIS L 1097.

11. The fiber wadding according to claim 10, wherein outside diameter of the biodegradable fibers is from about 0.1 μm to about 20 μm.