CLAIMS

1. A method of forming one or more protrusions on an outer surface of a polished facet of a solid state material, said method including the step of:

(i) applying focused inert gas ion beam local irradiation towards an outer surface of a polished facet of a solid state material in a way of protruding top surface material;

wherein irradiated focused inert gas ions from said focused inert gas ion beam penetrate the outer surface of said polished facet of said solid state material; and

wherein irradiated focused inert gas ions cause expansive strain within the solid state crystal lattice of the solid state material below said outer surface at a pressure so as to induce expansion of solid state crystal lattice, and form a protrusion on the outer surface of the polished facet of said solid state material.

2. A method of forming one or more protrusions according to claim 1, wherein said focused inert gas ion beam has a beam energy in the range of from 5keV to 50keV and probe current in the range of 1fA to 200pA.

3. A method of forming one or more protrusions according to claim 1 or claim 2 wherein the solid state crystal lattice is in a form of a single crystalline, poly-crystalline, or an amorphous form.

4. A method of forming one or more protrusions according to any one of claims 1 to 3, wherein the solid state material is a material in solid state form

under ambient temperature and under a pressure from atmospheric to high vacuum.

5. A method of forming one or more protrusions according to any one of claims 1 to 4, wherein the solid state material is a precious stone.

6. A method of forming one or more protrusions according to any one of the preceding claims, wherein the solid state material is a material selected from the group including Diamond, Ruby, Sapphire, Emerald, Pearl, Jade or the like.

7. A method of forming one or more protrusions according to any one of the preceding claims, wherein the focused inert gas ion beam is an ion source from any inert gas in Group VIII of the periodic table.

8. A method of forming one or more protrusions according to any one of the preceding claims, wherein the polished facet of the solid state material has an average surface roughness of less than 50nm.

9. A method of forming one or more protrusions according to any one of the preceding claims, wherein said protrusion has an average width in the nanometer or micrometer order of magnitude, and an average height in the nanometer or micrometer order of magnitude.

10. A method of forming one or more protrusions according to any one of the preceding claims, wherein the distance from the outer surface of said solid state material to the region of irradiated inert gas accumulation below the outer surface is in the range of from 1nm to 100μm.

11. A method of forming one or more protrusions according to any one of the preceding claims, wherein said one or more protrusions is provided so as to form an identifiable mark or pattern.

12. A method of forming one or more protrusions according to claim 11, wherein the identifiable mark is in a form of a single or array of dot, pillar, dome, hemisphere, line, irregular shape, symmetric or asymmetric shape, or the like.

13. A method of forming one or more protrusions according to claim 11 or claim 12, wherein the identifiable mark is provided as a periodic line array, hole/dot array, circular array, spiral array, fractal array or multiple periods array, or the like.

14. A method of forming one or more protrusions according to any one of claim 11 to 13, wherein the identifiable mark is provided as a continuous protruded shape to form arbitrary patterns.

15. A method of forming one or more protrusions according to any one of the preceding claims, wherein a plurality of protrusions are formed and are nanometer sized so as to provide an information mark invisible to the naked eye due to Rayleigh Criterion in optical limit.

16. A method of forming one or more protrusions according to claim 15, wherein said protrusions are arranged in a periodic array viewable by specified lighting conditions and by a camera equipped microscope in the visible and invisible light range.

17. A method of forming one or more protrusions according to any one of the preceding claims, wherein said one or more protrusions forms an identifiable security mark.

18. A method of forming one or more protrusions according to any one of the preceding claims, wherein the integrity of said solid state material is preserved, and there exists substantially no loss in mass.

19. A solid state material having one or more protrusions formed on an outer surface of a polished facet of the solid state material, wherein said one or more protrusions are formed from a method including the step of:

(i) applying focused inert gas ion beam local irradiation towards an outer surface of a polished facet of a solid state material in a way of protruding top surface material;

wherein irradiated focused inert gas ions from said focused inert gas ion beam penetrate the outer surface of said polished facet of said solid state material; and irradiated focused inert gas ions cause expansive strain within the solid state crystal lattice of the solid state material below said outer surface at a pressure so as to induce expansion of solid state crystal lattice, and form a protrusion on the outer surface of the polished facet of said solid state material.

20. A solid state material according to claim 19, wherein said focused inert gas ion beam has a beam energy in the range of from 5keV to 50keV and probe current 1fA to 200pA.

21. A solid state material according to claim 19 or claim 20, wherein the solid state crystal lattice is in a form of single crystalline, poly–crystalline, or amorphous form.

22. A solid state material according to any one of claims 19 to 21 wherein the solid state material is a material in solid state form under ambient temperature and under a pressure from atmospheric to high vacuum.

23. A solid state material according to any one of claims 19 to 22 wherein the solid state material is a precious stone.

24. A solid state material according to any one of claims 19 to 23, wherein the solid state material is a material selected from the group including Diamond, Ruby, Sapphire, Emerald, Pearl, Jade or the like.

25. A solid state material according to any one of claims 19 to 24, wherein the focused inert gas ion beam utilised to form said one or more protrusions is an ion source from any inert gas in Group VIII of the periodic table.

26. A solid state material according to any one of claims 19 to 25, wherein the polished facet of the solid state material has an average surface roughness of less than 50nm.

27. A solid state material according to any one of claims 19 to 26, wherein said one or more protrusions has an average width in the nanometer or micrometer order of magnitude, and an average height in the nanometer or micrometer order of magnitude.

28. A solid state material according to any one of claims 19 to 27, wherein the distance from the outer surface of said solid state material to the region of irradiated inert gas accumulation below the outer surface is in the range of from 1nm to 100μm.

29. A solid state material according to any one of claims 19 to 28, wherein said protrusion is provided so as to form an identifiable mark or pattern.

30. A solid state material according to claim 29, wherein the identifiable mark is in a form of single or array of dot, pillar, dome, hemisphere, line, irregular shape, symmetric or asymmetric shape, or the like.

31. A solid state material according to claim 29 or claim 30 wherein the identifiable mark is provided as a periodic line array, hole/dot array, circular array, spiral array, fractal array or multiple periods array, or the like.

32. A solid state material according to any one of claims 19 to 31, wherein the identifiable mark is provided as a continuous protruded shape to form arbitrary patterns.

33. A solid state material according to any one of claims 19 to 32, wherein the solid state material has a plurality of protrusions formed which are nanometer sized so as so provide an information mark invisible to the naked eye due to Rayleigh Criterion in optical limit.

34. A solid state material according to any one of claims 19 to 33, wherein said one or more protrusions are arranged in a periodic array viewable by specified

lighting conditions and by a camera equipped microscope in the visible and invisible light range.

35. A solid state material according to any one of claims 19 to 34, wherein said one or more protrusions forms an identifiable security mark.

36. A solid state material according to any one of claims 19 to 35, wherein the integrity of said solid state material is preserved during formation of the one or more protrusions, and there exists substantially no loss in mass of the solid state material.

37. A system for forming one or more protrusions on an outer surface of a polished facet of a solid state material, said system including:

a focused inert gas ion beam device for applying focused inert gas ion bean local irradiation towards an outer surface of a polished facet of a solid state material;

a computer control device for controlling discharge of a focused inert gas ion beam local irradiation towards an outer surface of a polished facet of a solid state material;

wherein the computer control device controls irradiated focused inert gas ions from said focused inert gas ion beam so as to penetrate the outer surface of said polished facet of said solid state material; and irradiated focused inert gas ions cause expansive strain within the solid state crystal lattice of the solid state material below said outer surface at a pressure so as to induce expansion of solid

state crystal lattice, and so as to form a protrusion on the outer surface of the polished facet of said solid state material.

38. A system according to claim 37, wherein said focused inert gas ion beam device has a beam energy in the range of from 5keV to 50keV and probe current in the range of 1fA to 200pA.

39. A system according to claim 37 or claim 38, wherein the focused inert gas ion beam utilised to form said one or more protrusions is an ion source from any inert gas in Group VIII of the periodic table.

40. A system according to any one of claims 37 to 39, wherein said system provides one or more protrusions having an average width in the nanometer or micrometer order of magnitude, and an average height in the nanometer or micrometer order of magnitude.

41. A system according to any one of claim 37 to 40, wherein the system is adapted to provide one or more protrusions whereby the distance from the outer surface of said solid state material to the region of irradiated inert gas accumulation below the outer surface is in the range of from 1nm to 100μm.

42. A system according to any one of claims 37 to 41, wherein the system is adapted so as to provide an identifiable mark or pattern on an outer surface of a polished facet of a solid state material.

43. A system according to claim 42, wherein the identifiable mark provided by the system is in a form of single or array of dot, pillar, dome, hemisphere, line, irregular shape, symmetric or asymmetric shape, or the like.

44. A system according to claim 42 or claim 43, wherein the identifiable mark is provided as a periodic line array, hole/dot array, circular array, spiral array, fractal array or multiple periods array, or the like.

45. A system according to any one of claims 42 to 44, wherein the identifiable mark is provided as a continuous protruded shape to form arbitrary patterns.

46. A system according to any one of claims 37 to 45, wherein the system is adapted to provide a plurality of protrusions which are nanometer sized so as to provide an information mark invisible to the naked eye due to Rayleigh Criterion in optical limit.

47. A system according to any one of claims 37 to 46, wherein the system is adapted to provide a plurality of protrusions which are arranged in a periodic array viewable by specified lighting conditions and by a camera equipped microscope in the visible and invisible light range.

48. A system according to any one of claims 37 to 47, wherein the system is adapted to provide one or more protrusions so as to form an identifiable security mark.

49. A system according to any one of claims 37 to 48, wherein the system is adapted so as to maintain the integrity of said solid state material during formation of the one or more protrusions, and such that there exists substantially no loss in mass of the solid state material.

50. A system according to any one of claims 37 to 49, wherein the system is adapted so as to provide one or more protrusions on the outer surface of a precious stone.

51. A system according to any one of claims 37 to 50, wherein the system is adapted so as to provide one or more protrusions on the outer surface of a Diamond, Ruby, Sapphire, Emerald, Pearl, Jade or the like.

52. A system according to any one of claims 37 to 51, wherein the system is adapted so as to provide one or more protrusions on a polished facet of the solid state material having an average surface roughness of less than 50nm.

53. A system according to any one of claims 37 to 52, wherein the system is adapted so as to provide one or more protrusions on the outer surface of a solid state material, wherein the one or more protrusions has an average width in the nanometer or micrometer order of magnitude, and an average height in the nanometer or micrometer order of magnitude.

54. A system according to any one of claims 37 to 53 , wherein the system is adapted so as to provide one or more protrusions on the outer surface of a solid state material such that the region of irradiated inert gas accumulation below the outer surface is in the range of from 1nm to 100μm.

CLAIMS

1. A method of forming one or more protrusions on an outer surface of a polished facet of a solid state material, said method including the step of:

(i) applying focused inert gas ion beam local irradiation towards an outer surface of a polished facet of a solid state material in a way of protruding top surface material;

wherein irradiated focused inert gas ions from said focused inert gas ion beam penetrate the outer surface of said polished facet of said solid state material;

wherein irradiated focused inert gas ions cause expansive strain within the solid state crystal lattice of the solid state material below said outer surface at a pressure so as to induce expansion of solid state crystal lattice, and form a protrusion on the outer surface of the polished facet of said solid state material; and

wherein the solid state material is a precious stone.

2. A method of forming one or more protrusions according to claim 1, wherein said focused inert gas ion beam has a beam energy in the range of from 5keV to 50keV and probe current in the range of 1fA to 200pA.

3. A method of forming one or more protrusions according to claim 1 or claim 2 wherein the solid state crystal lattice is in a form of a single crystalline, poly-crystalline, or an amorphous form.

4. A method of forming one or more protrusions according to any one of claims 1 to 3, wherein the solid state material is a material in solid state form under ambient temperature and under a pressure from atmospheric to high vacuum.

5. A method of forming one or more protrusions according to any one of the preceding claims, wherein the solid state material is a material selected from the group consisting of Diamond, Ruby, Sapphire, Emerald, Pearl and Jade.

6. A method of forming one or more protrusions according to any one of the preceding claims, wherein the focused inert gas ion beam is an ion source from any inert gas in Group VIII of the periodic table.

7 A method of forming one or more protrusions according to any one of the preceding claims, wherein the polished facet of the solid state material has an average surface roughness of less than 50nm.

8. A method of forming one or more protrusions according to any one of the preceding claims, wherein said protrusion has an average width in the nanometer or micrometer order of magnitude, and an average height in the nanometer or micrometer order of magnitude.

9. A method of forming one or more protrusions according to any one of the preceding claims, wherein the distance from the outer surface of said solid state material to the region of irradiated inert gas accumulation below the outer surface is in the range of from 1nm to 100µm.

10. A method of forming one or more protrusions according to any one of the preceding claims, wherein said one or more protrusions is provided so as to form an identifiable mark or pattern.

11. A method of forming one or more protrusions according to claim 10, wherein the identifiable mark is in a form of a single or array of dot, pillar, dome, hemisphere, line, irregular shape, symmetric or asymmetric shape, or the like.

12. A method of forming one or more protrusions according to claim 10 or claim 11, wherein the identifiable mark is provided as a periodic line array, hole/dot array, circular array, spiral array, fractal array or multiple periods array, or the like.

13. A method of forming one or more protrusions according to any one of claim 10 to 12, wherein the identifiable mark is provided as a continuous protruded shape to form arbitrary patterns.

14. A method of forming one or more protrusions according to any one of the preceding claims, wherein a plurality of protrusions are formed and are nanometer sized so as to provide an information mark invisible to the naked eye due to Rayleigh Criterion in optical limit; and

wherein said protrusions are arranged in a periodic array viewable by specified lighting conditions and by a camera equipped microscope in the visible and invisible light range.

15. A method of forming one or more protrusions according to any one of the preceding claims, wherein said one or more protrusions forms an identifiable security mark.

16. A method of forming one or more protrusions according to any one of the preceding claims, wherein the integrity of said solid state material is preserved, and there exists substantially no loss in mass.

17. A solid state material having one or more protrusions formed on an outer surface of a polished facet of the solid state material, wherein said one or more protrusions are formed from a method including the step of:

(i) applying focused inert gas ion beam local irradiation towards an outer surface of a polished facet of a solid state material in a way of protruding top surface material;

wherein irradiated focused inert gas ions from said focused inert gas ion beam penetrate the outer surface of said polished facet of said solid state material; and irradiated focused inert gas ions cause expansive strain within the solid state crystal lattice of the solid state material below said outer surface at a pressure so as to induce expansion of solid state crystal lattice, and form a protrusion on the outer surface of the polished facet of said solid state material; and

wherein the solid state material is a precious stone.

18. A solid state material according to claim 17, wherein said focused inert gas ion beam has a beam energy in the range of from 5keV to 50keV and probe current 1fA to 200pA.

19. A solid state material according to claim 17 or claim 18, wherein the solid state crystal lattice is in a form of single crystalline, poly–crystalline, or amorphous form.

20. A solid state material according to any one of claims 17 to 19 wherein the solid state material is a material in solid state form under ambient temperature and under a pressure from atmospheric to high vacuum.

21. A solid state material according to any one of claims 17 to 20, wherein the solid state material is a material selected from the group consisting of Diamond, Ruby, Sapphire, Emerald, Pearl and Jade.

22. A solid state material according to any one of claims 17 to 21, wherein the focused inert gas ion beam utilised to form said one or more protrusions is an ion source from any inert gas in Group VIII of the periodic table.

23. A solid state material according to any one of claims 17 to 22, wherein the polished facet of the solid state material has an average surface roughness of less than 50nm.

24. A solid state material according to any one of claims 17 to 23, wherein said one or more protrusions has an average width in the nanometer or micrometer order of magnitude, and an average height in the nanometer or micrometer order of magnitude.

25. A solid state material according to any one of claims 17 to 24, wherein the distance from the outer surface of said solid state material to the region of irradiated inert gas accumulation below the outer surface is in the range of from 1nm to 100µm.

26. A solid state material according to any one of claims 17 to 25, wherein said protrusion is provided so as to form an identifiable mark or pattern.

27. A solid state material according to claim 26, wherein the identifiable mark is in a form of single or array of dot, pillar, dome, hemisphere, line, irregular shape, symmetric or asymmetric shape, or the like.

28. A solid state material according to claim 26 or claim 27 wherein the identifiable mark is provided as a periodic line array, hole/dot array, circular array, spiral array, fractal array or multiple periods array, or the like.

29. A solid state material according to any one of claims 17 to 28, wherein the identifiable mark is provided as a continuous protruded shape to form arbitrary patterns.

30. A solid state material according to any one of claims 17 to 29, wherein the solid state material has a plurality of protrusions formed which are nanometer sized so as so provide an information mark invisible to the naked eye due to Rayleigh Criterion in optical limit; and

wherein said one or more protrusions are arranged in a periodic array viewable by specified lighting conditions and by a camera equipped microscope in the visible and invisible light range.

31. A solid state material according to any one of claims 17 to 30, wherein said one or more protrusions forms an identifiable security mark.

32. A solid state material according to any one of claims 17 to 31, wherein the integrity of said solid state material is preserved during formation of the one or more protrusions, and there exists substantially no loss in mass of the solid state material.