Nevertheless, there is a need for coloured sapphire materials that can be useful for numerous uses.

As for example, jewellery may take advantage of sapphire material mechanical properties and desire to obtain a wide range of colour for said material that could be adjusted or chosen according to design or esthetical needs.

As for another example, the lighting industry may also need coloured sapphire materials to manufacture coloured filters.

As for another example, the screen industry may also need coloured sapphire materials to manufacture coloured screens.

Summary

In one aspect, there is provided a treatment method for modifying a reflected colour of a sapphire material surface comprising bombardment by a single- and/or multi-charged gas ion beam so as to produce an ion implanted layer in the sapphire material, wherein:

- an acceleration voltage is chosen in a range between 5kV and 1000 kV;
- a dose of implanted single- and/or multi-charged gas ions per unit of surface area of each ion beam is chosen in a range between 10^{16} ions/cm^2 and 10^{18} ions/cm^2; the acceleration voltage is chosen in a range between 10 kV and 100 kV; and,
- the single- and/or multi-charged gas ions are selected from ions of elements from the list consisting of helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), boron (B), carbon (C), nitrogen (N), oxygen (O), fluorine (F), silicon (Si), phosphorus (P) and sulphur (S)

wherein the dose of implanted single- and/or multi-charged gas ions and the acceleration voltage are chosen so as to obtain a modified reflected colour of the treated sapphire material surface compared to the untreated sapphire material surface.

In another aspect, there is provided a part made of synthetic sapphire material comprising at least one surface treated according to the method as disclosed herein, wherein the dominant wavelength, λ_{DT}, of the reflected colour of the treated surface is shifted from at least +50 nm or at least –50

nm from the dominant wavelength, λ_{DU}, of the reflected colour of the untreated sapphire material surface, as for example shifted from at least +100 nm or at least –100 nm.

In a further aspect, there is provided a use of the treatment method as disclosed herein, for treating a solid part made of synthetic sapphire material chosen from the list consisting of a screen, such as for example a touch screen, a window, a watch glass, a lighting device part, such as a light emitting device (LED) part, an optical component, such as for example device lens.

Detailed Disclosure of Embodiments

The aim of the invention is that of offering a method for modifying the reflected colour of a sapphire material that open new routes; preferably, said method is not expensive or even though inexpensive and suitable for treating surfaces meeting the needs of numerous applications.

For this purpose, an object of the invention is a treatment method for modifying the reflected colour of a sapphire material surface comprising bombardment by a single- and/or multi-charged gas ion beam so as to produce an ion implanted layer in the sapphire material, wherein:

- the acceleration voltage is chosen in a range between 5kV and 1000 kV;
- the dose of implanted single- and/or multi-charged gas ions per unit of surface area of each ion beam is chosen in a range between 10^{12} ions/cm^2 and 10^{18} ions/cm^2; and,
- the dose of implanted single- and/or multi-charged gas ions and the acceleration voltage are further chosen so that to obtain a modified reflected colour of the treated sapphire material surface compared to the untreated sapphire material surface ; and,
- the ions of the single- and/or multi-charged gas ions are selected from ions of the elements from the list consisting of helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), boron (B), carbon (C), nitrogen (N), oxygen (O), fluorine (F), silicon (Si), phosphorus (P) and sulphur (S).

CLAIMS

1. A treatment method for modifying a reflected colour of a sapphire material surface comprising bombardment by a single- and/or multi-charged gas ion beam so as to produce an ion implanted layer in the sapphire material, wherein:

- a dose of implanted single- and/or multi-charged gas ions per unit of surface area of each ion beam is chosen in a range between 10^{16} ions/cm^2 and 10^{18} ions/cm^2;
- an acceleration voltage is chosen in a range between 10 kV and 100 kV; and,
- the single- and/or multi-charged gas ions are selected from ions of elements from the list consisting of helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), boron (B), carbon (C), nitrogen (N), oxygen (O), fluorine (F), silicon (Si), phosphorus (P) and sulphur (S),

wherein the dose of implanted single- and/or multi-charged gas ions and the acceleration voltage are chosen so as to obtain a modified reflected colour of the treated sapphire material surface compared to the untreated sapphire material surface.

2. The treatment method of claim 1, wherein the single- and/or multi-charged gas ions are selected from ions of the elements from the list consisting of helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), nitrogen (N) and oxygen (O), for example from the list consisting of nitrogen (N) and oxygen (O), for example the single- and/or multi-charged gas ions are ions of oxygen (O).

3. The treatment method of any one of the preceding claims, wherein the ions for bombardment by a single- and/or multi-charged gas ion beam are produced by an electron cyclotron resonance (ECR) source.

4. The treatment method of any one of the preceding claims, wherein the ions of the gas beam are single- and multi-charged and comprise 10% multi-charged ions or more than 10% multi-charged ions.

5. The treatment method of any one of the preceding claims, wherein the dose of implanted single- and/or multi-charged gas ions per unit of surface area is chosen in a range between 2.10^{16} ions/cm^2 and 2.10^{17} ions/cm^2.

6. The treatment method of any one of the preceding claims, wherein the dose of implanted single- and/or multi-charged gas ions per unit of surface area is chosen to obtain an atomic concentration of implanted ions greater or equal to 5% and equal or less than 20%.

7. The treatment method of any one of the preceding claims, wherein the sapphire material is movable in relation to the single- and/and multi-charged gas ion beam at a speed, V_D, of between 0.1 mm/s and 1000 mm/s.

8. The treatment method of claim 7, wherein one and same zone of the sapphire material is moved under the single- and/or multi-charged gas ion beam along a plurality, NP, of passes at the speed V_D.

9. The treatment method of any one of the preceding claims, wherein the treatment method comprises bombardment of the sapphire material surface by a plurality of single- and/or multi-charged gas ion beams so as to produce an ion implanted layer in the sapphire material, and wherein the acceleration voltage and/or the element of the ion beams differ(s) from a gas ion beam to another gas ion beam.

10. The treatment method of any one of the preceding claims, comprising bombardment of a first and a second sapphire material surface, each by one or by a plurality of single- and/or multi-charged gas ion beam(s) so as to produce in the sapphire material an ion implanted layer on the first sapphire material surface and an ion implanted layer on the second sapphire material surface, wherein the first and the second sapphire material surfaces are substantially parallel surfaces separated by a transparent medium and wherein the acceleration voltage and/or the element of the ion beam for the treatment of the second sapphire material surface differ(s) from respectively the acceleration voltage and/or the element of the ion beam(s) for the treatment of the first sapphire material surface.

11. The treatment method of claims 9 or 10, wherein the ions of the different gas ion beams are ions of one and same element and wherein the acceleration voltage of the ions beams differs from a gas ion beam to another gas ion beam.

12. The treatment method of claim 11, wherein the acceleration voltage of the ion beams differs from a value comprised between 5 and 50 kV, for example from a value comprised between 10 and 20 kV.

13. The treatment method of any one of the preceding claims wherein the acceleration voltage and the dose of implanted single- and/or multi-charged gas ions are further chosen according to the following steps:

- a step prior to bombardment of the sapphire material to be treated, which consists of choosing one type of single- and/or multi-charged ions of the elements from the list consisting of helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), boron (B), carbon (C), nitrogen (N), oxygen (O), fluorine (F), silicon (Si), phosphorus (P) and

sulphur (S), performing a plurality of experiments with sapphire materials similar to the one to be treated using ions of the type chosen, and varying the implanted single- and/or multi-charged gas ion dose per unit of surface area and the acceleration voltage until determining desired implanted single- and/or multi-charged gas ion dose per unit of surface area ranges and acceleration voltage ranges so as to produce an ion implanted layer suitable for obtaining a modified reflected colour of the sapphire material surface;

- gathering and handling data obtained in said step prior to bombardment of the sapphire material to be treated, so as to provide guidelines of colour variation of a sapphire surface according to the element of the single- and/or multi-charged ion beam, the acceleration voltage and the ion dose per unit of surface area;

- choosing a single- and/or multi-charged gas ion dose per unit of surface area and an acceleration voltage value from the data gathered in said step prior to bombardment of the sapphire material to be treated; and treating the sapphire material to be treated with said ions and said values.

14. The treatment method of claim 13, wherein the choice of the element of the single- and/or multi-charged ion beam, of the single- and/or multi-charged gas ion dose per unit of surface area and of the acceleration voltage value is done so as to fulfil requirements of a colour target for the reflected colour of the sapphire material surface.

15. The treatment method of any one of the preceding claims, for treating a solid part made of synthetic sapphire material chosen from the list consisting of a screen, such as for example a touch screen, a window, a watch glass, a lighting device part, such as a light emitting device (LED) part, an optical component, such as for example a device lens.

16. A part made of synthetic sapphire material, comprising at least one surface treated according to the method of any one of the preceding claims, wherein a dominant wavelength, λ_{DT}, of the reflected colour of the treated

surface is shifted from at least +50 nm or at least –50 nm from the dominant wavelength, λ_{DU}, of the reflected colour of the untreated sapphire material surface, as for example shifted from at least +100 nm or at least –100 nm.