CLAIMS

What is Claimed:

1. A method for treating a superalloy substrate (32) which includes at least one cavity (33) containing adherent metal oxide material on its surface (31), comprising the step of directing a short-pulsed, high repetition rate laser beam (46) against the cavity surface for a period of time sufficient to remove substantially all of the adherent metal oxide material, wherein the laser beam (46) is characterized by a peak power density in the range of about 10 megawatts/cm^2 to about 10 gigawatts/cm^2.

2. The method of claim 1, wherein the laser beam pulses have a pulse length of from about 1 nanosecond to about 1 microsecond.

3. The method of claim 1, wherein the source (44) of the laser beam (46) is a device selected from the group consisting of a solid-state laser, a fiber laser, and an excimer laser.

4. The method of claim 1, wherein the laser beam (46) is focused on the cavity surface (31) through a scanning module (48).

5. The method of claim 1, wherein the cavity is a crack (33) within the superalloy substrate (32).

6. The method of claim 1, wherein the adherent metal oxide on the cavity surface (31) comprises at least one material selected from the group consisting of aluminum oxide, zirconium oxide, nickel oxide, chromium oxide, molybdenum oxide, and calcium-magnesium-aluminum-silicon oxide (CMAS).

7. The method of claim 1, wherein the superalloy substrate (10) is a turbine engine component.

8. The method of claim 1, wherein the cavity (33) is a crack, and said method further includes the step of repairing the crack.

9. A method for treating a superalloy substrate (64) which includes at least one cavity (60) containing adherent metal oxide material on its surface (62), comprising the step of directing a high-power, short-pulsed, high repetition rate laser beam (46) to a region on the substrate (62) which includes the cavity (60), under laser operational conditions which are capable of cutting into the superalloy material; so that a boundary region (66) is formed within the substrate (64), which encloses the cavity (60).

10. The method of claim 9, wherein at least one additional treatment step is carried out on the substrate (64) prior to any cavity repair step, and the additional treatment step comprises a laser cleaning step.

CLAIMS

1. A method for treating a superalloy substrate which includes at least one cavity containing adherent metal oxide material on its surface, comprising the steps of: contacting the cavity surface with a forming gas; and directing a short-pulsed, high repetition rate laser beam against the cavity surface for a period of time sufficient to remove substantially all of the adherent metal oxide material, wherein the laser beam is characterized by a peak power density in the range of about 500 megawatts/cm2 to about 10 gigawatts/cm2; sufficient to cause laser ablation of metal oxide material.

2. The method of claim 1, wherein the laser beam pulses have a pulse length of from about 1 nanosecond to about 1 microsecond.

3. The method of claim 2, wherein the laser beam pulses have a pulse length of from about 1 nanosecond to about 20 nanoseconds.

4. The method of claim 1, wherein the repetition rate of the laser beam is at least about 100 Hz.

5. The method of claim 1, wherein the source of the laser beam is a device selected from the group consisting of a solid-state laser, a fiber laser, and an excimer laser.

6. The method of claim 1, wherein the laser beam is focused on the cavity surface through a scanning module.

7. The method of claim 6, wherein the scanning module comprises a galvo scanner or a piezo scanner.

8. The method of claim 1, wherein the cavity is a crack within the superalloy substrate.

9. The method of claim 8, wherein the crack is substantially perpendicular to a surface of the superalloy substrate.

10. The method of claim 8, wherein the crack has a depth of at least about 25 microns.

11. The method of claim 10, wherein the crack has a depth in the range of about 25 microns to about 10 mm.

12. The method of claim 10, wherein the crack has a width in the range of about 5 microns to about 4 mm.

13. The method of claim 1, wherein the adherent metal oxide on the cavity surface comprises at least one material selected from the group consisting of aluminum oxide, zirconium oxide, nickel oxide, chromium oxide, molybdenum oxide, and calcium-magnesium-aluminum-silicon oxide (CMAS).

14. The method of claim 1, wherein the superalloy substrate comprises at least one metal selected from the group consisting of nickel, cobalt, and iron.

15. The method of claim 1, wherein the superalloy substrate is a turbine engine component.

16. The method of claim 15, wherein the turbine engine component is a turbine blade.

17. The method of claim 16, wherein the turbine blade includes a tip portion, and the cavity is a crack in the tip portion.

18. The method of claim 1, wherein the cavity is a crack, and said method further includes the step of repairing the crack.

19. The method of claim 18, wherein the crack is repaired by at least one technique selected from the group consisting of welding, diffusion brazing, activated diffusion healing (ADH), and a thermal spray technique.

20. The method of claim 19, wherein the welding technique is selected from the group consisting of arc welding and gas welding.

21. The method of claim 19, wherein the welding technique comprises tungsten inert gas (TIG) welding or metal inert gas (MIG) welding.

22. A method for treating a superalloy substrate which includes at least one cavity containing adherent metal oxide material on its surface, comprising the steps of: contacting the cavity surface with a forming gas; and directing a high-

power, short-pulsed, high repetition rate laser beam to a region on the substrate which includes the cavity, under laser operational conditions which are capable of cutting into the superalloy material; so that a boundary region is formed within the substrate, which encloses the cavity, wherein the laser beam is characterized by a peak power density in the range of about 500 megawatts/cm2 to about 10gigawatts/cm2, and is sufficient to cause laser ablation of metal oxide material.

23. The method of claim 22, wherein the laser beam is focused on the substrate through a scanning module.

24. The method of claim 22, wherein the cavity comprises walls which define its shape; and the boundary region is relatively uniform and smooth, as compared to the walls of the cavity.

25. The method of claim 22, wherein the boundary region is filled with a replacement material after being formed.

26. The method of claim 22, wherein the cavity is a crack, and the superalloy substrate is a turbine blade.

27. The method of claim 22, wherein at least one additional treatment step is carried out on the substrate prior to any cavity repair step.

28. The method of claim 27, wherein the additional treatment step comprises a laser cleaning step.

29. A method for repairing a crack in a superalloy-based surface of a turbine component, wherein the crack contains adherent metal oxide material on its surface, said method comprising the following steps: contacting the cavity surface with a forming gas: directing a high-power, short-pulsed, high repetition rate laser beam to a region on the substrate which includes the cavity, under laser operational conditions which are capable of cutting into the superalloy material and is sufficient to cause laser ablation of metal oxide material; so that a boundary region is formed within the substrate, which encloses the cavity, wherein the laser beam is characterized by a peak power density in the range of about 500 megawatts/cm2 to about 10 gigawatts/cm2; and filling the boundary region with a replacement material, by a welding technique.

30. The method of claim 29, wherein the welding technique comprises tungsten inert gas (TIG) welding).