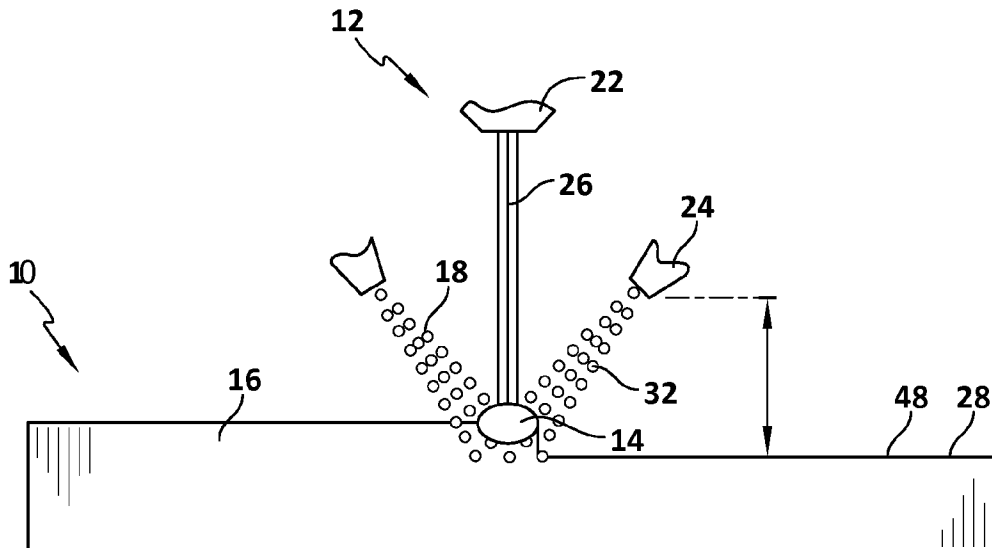




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(54) Title: LASER DEPOSITION USING A PROTRUSION TECHNIQUE



(57) **Abrégé/Abstract:**

A method of applying a laser metal formed build layer (16) on a surface of an article (10). The surface of the article (10) is melted locally using a power source (22) to form a melt pool (14). Powdered metal (18, 32) is injected into the melt pool (14). The melt pool (14) is solidified to form the first protrusion. A build layer (16) having a desired microstructure and geometry on the surface of the article (10) is eventually formed.

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(54) Title: LASER DEPOSITION USING A PROTRUSION TECHNIQUE

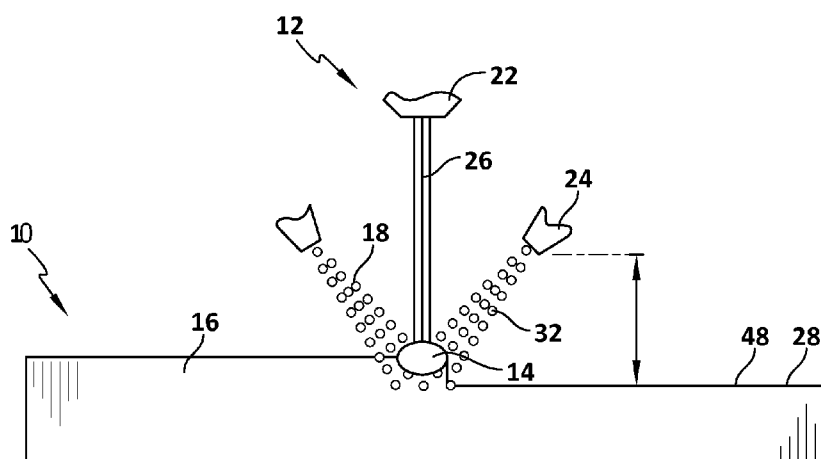


FIG. 1

(57) Abstract: A method of applying a laser metal formed build layer (16) on a surface of an article (10). The surface of the article (10) is melted locally using a power source (22) to form a melt pool (14). Powdered metal (18, 32) is injected into the melt pool (14). The melt pool (14) is solidified to form the first protrusion. A build layer (16) having a desired microstructure and geometry on the surface of the article (10) is eventually formed.

LASER DEPOSITION USING A PROTRUSION TECHNIQUE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of U.S. Application Number 61/778,598, filed 13 March 2013.

FIELD OF THE DISCLOSURE:

[0002] The present disclosure relates generally to a method of applying a metal build layer to a surface of a workpiece using laser deposition and more specifically to a method of applying a metal build layer to a surface of a workpiece using laser deposition resulting in a desired build out geometry.

BACKGROUND

[0003] Structures and components may be formed by successive deposition of materials. One example technique of such structure and component deposition is by direct laser deposition (DLD). During direct laser deposition, a source of deposition material, for example wire, powder, or ribbon, is presented below a laser beam such that the laser beam heats the deposition material. The deposition material melts and, when re-solidified, becomes an integral part of a component structure.

[0004] Adding material to the component structure in this way is typically performed by individual build layers. Each build layer is formed on top of the previous build layer, resulting in a laser deposition build. As indicated, wires or powders are used for the deposition material. Consistency of deposition, however, may be difficult.

[0005] Laser deposition builds, especially on thin edges or thin airfoils, tend not to build out or maintain the desired geometric shape at the edges and corners of the build. Use of excessive power to generate a large melt pool and build profile can be used to obtain the correct build out geometry, but, in most cases, will negatively affect the microstructure of the laser deposition build.

SUMMARY

[0006] The present application discloses one or more of the features recited in the appended claims and/or the following features which, alone or in any combination, may comprise patentable subject matter.

[0007] According to some embodiments disclosed herein, there is provided a method of applying a laser metal formed build layer on a surface of an article, the method comprising the operations of surveying a first portion of an article to form a build layer thereon using a laser deposition process, identifying an area of the first portion with an increased risk of forming the build layer with at least one of an undesirable geometry and microstructure as a result of undergoing the laser deposition process, determining a first location for forming a first protrusion within the identified area, melting the article at the first location using a power source to establish a first melt pool, injecting deposition material into the first melt pool, solidifying the first melt pool to form the first protrusion, the first protrusion having a first microstructure, determining a second location for forming a second protrusion within the identified area, melting the article at the second location using a power source to establish a second melt pool, injecting deposition material into the second melt pool, and solidifying the second melt pool to form the second protrusion, the second protrusion having the first microstructure, melting the first portion of the article, including the first protrusion and the second protrusion, using the power source to establish a number of melt pools, injecting deposition material into the number of melt pools, and solidifying the number of melt pools to form the build layer on the first portion of the article, the build layer having a desired geometry and a second microstructure.

[0008] In some embodiments, the method may include the steps of melting, at low heat, the first protrusion using the power source to establish a second melt pool, injecting deposition material into the second melt pool, and solidifying the second melt pool to increase the size of the first protrusion, the first protrusion retaining the first microstructure. In some embodiments, the method may include the steps of melting, at low heat, the first portion of the article, including the first protrusion, using the power source to establish a number of melt pools, injecting deposition material into the number of melt pools, solidifying the number of melt pools to form a build layer on the first portion of the article, the build layer having a desired geometry and a second microstructure.

[0009] In some embodiments, the second microstructure may be about the same as the first microstructure. In some embodiments, the article may have a third microstructure and the first microstructure of the first protrusion, the second microstructure of the build layer, and the third microstructure of the article may be about the same.

[0010] In some embodiments, melting, at low heat, the article at the first location using a power source to establish a first melt pool may be performed by a pulsing power light source. In some embodiments, melting, at low heat, the first portion of the article, including the first protrusion, using the light source to establish a number of melt pools may be performed by a continuous power light source.

[0011] In some embodiments, the area of the first portion with an increased risk of forming the build layer with at least one of an undesirable geometry and microstructure as a result of undergoing the laser deposition process may include at

least one of an edge and a corner of the article. In some embodiments, the method may include the steps of determining a second location for forming a second protrusion within the identified area, melting, at low heat, the article at the second location using a light source to establish a second melt pool, injecting deposition material into the second melt pool, and solidifying the second melt pool to form the second protrusion, the second protrusion having the first microstructure.

[0012] In some embodiments, the pulsing power source turns off and on at specific time intervals.

[0013] In some embodiments, the pulsing power source increases and decreases in intensity at specific time intervals.

[0014] These and other features of the present disclosure will become more apparent from the following description of the illustrative embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Fig. 1 is a side elevation view of a portion of a laser deposition process showing a damaged component and a laser deposition head spaced apart from the damaged component, the laser deposition head producing a laser beam aimed at a surface of the component to produce a melt pool on a metal substrate of the surface and depositing a powdered metal feedstock into the melt pool and suggesting that a metal build layer, integrated with the surface, remains after the melt pool cools;

[0016] Fig. 2 is a side elevation view of a portion of the damaged component of Fig. 1 showing that the component has a material defect portion in need of repair and that the material defect portion includes a corner and edge of the component;

[0017] Fig. 2A is a side elevation view of the portion of the damaged component of Fig. 2 showing that at least one protrusion has been formed in a risk area of the material defect portion prior to a first build layer being formed on the material defect portion such that the first build layer will form with a desired geometry and microstructure;

[0018] Fig. 2B is a plan view of the portion of the damaged component of Fig. 2A showing two protrusions formed in the risk area of the material defect portion prior to the first build layer being formed on the material defect portion such that the first build layer will form a desired geometry and microstructure;

[0019] Fig. 3 is a side elevation view of a portion of the damaged component of Fig. 2 that was repaired using a laser deposition technique without forming the protrusions in the risk area of the portion, the damaged component having a geometrically incorrect corner and edge after the repair as a result of not forming the protrusions during the laser deposition technique used to repair the damaged component; and

[0020] Fig. 4 is a side elevation view of a portion of the damaged component of Fig. 2 that was completely repaired by forming the protrusions during the laser deposition technique in accordance with the present disclosure, the damaged component having a corner and edges with a correct geometry and microstructure after the repair as a result of the protrusions being formed during the laser deposition technique used to repair the damaged component.

DETAILED DESCRIPTION OF THE DRAWINGS

[0021] For the purposes of promoting an understanding of the principles of the disclosure, reference will now be made to a number of illustrative embodiments illustrated in the drawings and specific language will be used to describe the same.

[0022] A method of a portion of a laser blown powder deposition technique used manufacture or restore a workpiece 10 is disclosed. The workpiece 10 may be, for example, a vane or blade of a gas turbine engine. In the illustrative embodiment, the workpiece 10 is a damaged component 10 as shown in Fig. 2. The component 10 is formed from at least one of a variety of materials. For example, the component 10 may be formed from nickel, titanium, cobalt, or steel alloys. As shown in Fig. 1, the method of manufacturing or restoring the component 10 uses a laser deposition head 12 to produce a melt pool 14 in a portion 28 of the component 10 and inject deposition material 18 into the melt pool 14. The melt pool 14 is then allowed to cool and a build layer 16, integrated with the component 10, remains.

[0023] In the illustrative embodiment, the laser deposition head 12 includes a power source 22 and at least one nozzle 24. In the illustrative embodiment, the power source 22 is a light source 22, for example, a laser. The light source 22 has a variable power. In the illustrative embodiment, the power is a specific power and remains substantially constant during the laser deposition process. In the illustrative embodiment, the power is set to produce a low heat melt pool 14 that cools to form a

build layer 16 with a desired microstructure. The light source 22 directs a beam of light 26 at a first portion 28 of the component 10 to heat and melt, locally, an area 30 of the first portion 28 to produce melt pool 14.

[0024] The nozzle 24 is connected to a powder feeder containing deposition material 18. The nozzle 24 sprays a deposition material flow 32 (also called powdered-metal flow 32) containing the deposition material 18 (also called powdered metal 18) at a flow rate. The powdered-metal flow 32 may have a variable flow rate. In the illustrative embodiment, the flow rate is constant. The nozzle 24 is oriented such that the powdered-metal flow 32 sprays towards the beam of light 26 and the melt pool 14 as shown in Fig. 1. As such, the powdered metal 18 from the nozzle 24 is injected into the melt pool 14. The laser deposition head 12 is moved away from the first portion 28 and the melt pool 14 is allowed to cool. As the melt pool 14 cools, the build layer 16 develops on the portion 28 due to the injected powdered metal 18.

[0025] A first portion 28 of the component 10 may include risk areas 30 with an increased risk of forming the build layer 16 with undesired geometry and/or microstructure as shown in Fig. 2. For example, corners and edges 38 of component 10 may be areas with an increased risk of forming the build layer 16 with an undesired geometry and/or microstructure. The corners and edges 38 may be thin and the melt pool 14 produced at the corners and edges 38 may cause the geometry of the component 10 to deform. The build layer 16 is then formed on the deformation, causing the build layer to have an undesirable geometry, as shown in Fig. 3. As an example, the build layers 16 result in an overall build 42 that does not build out to an edge 38 of component 10 as shown in Fig. 3. As such, the component 10 of Fig. 3 has an undesirable geometry.

[0026] The component 10 may be heated to high temperatures to produce a large melt pool 14 at the corner and edges 38 of component 10 and inject a large amount of powdered metal 18 into melt pool 14. This process produces corners and edges 38 with desirable geometry; however, the microstructure of the build layer 16 is undesirable due to the high temperatures of melt pool 14.

[0027] In accordance with the present disclosure, laser parameters and tool paths are determined to create a number of build layers 16 and an overall build 42 with a desired geometry and microstructure 40. The portion 28 of the component 10 is first surveyed to create information relating to the shape and contour of the portion 28

receiving build layers 16. In the illustrative embodiment, the survey is performed by geometrically scanning the candidate component 10. An adaptive model of the portion 28 is created from the scanned model and the adaptive model is used to generate a build model of the portion 28. The build model is then sliced into layers representing the build height of each build layer 16.

[0028] After the survey, the risk areas 30 of the portion 28 having an increased risk of forming the build layers 16 with undesirable geometry or microstructure are identified. The risk areas 30 may be, for example, corners and edges of the component 10.

[0029] A first location 48 of the risk area 30 to form a protrusion 36 is determined as shown in Fig. 2B. The protrusions 36 add extra material to the risk area 30. The extra material allows the build layer 16 to form with a desired geometry and microstructure at the risk area 30.

[0030] The first location 48 is melted to produce a first melt pool 14 using the light source 22 at a low heat. In some embodiments, the light source 22 is continuously on for a specific time to produce the first melt pool 14. In some embodiments, the light source 22 is pulsed at specific time intervals to produce the first melt pool 14. In one example, pulsed means that the light source 22 is turned on and off at specific intervals. In another example, pulsed means that intensity of the light source is increased and decreased at specific intervals.

[0031] The specific amount of powdered metal 18 is injected into the first melt pool 14. The specific amount of powdered metal 18 is determined such that the protrusion 36 is a specific size. In some embodiments, the size of protrusion 36 has a specific height and diameter. The first melt pool 14 is allowed to cool to form the first protrusion 36 as shown in Figs. 2A and 2B. The heat used to create first melt pool causes protrusion 36 to have a first microstructure 54.

[0032] In some embodiments, the first protrusion 36 is melted using the light source 22 to form a second melt pool 50. In the illustrative embodiment, second melt pool is formed using low heat. A specific amount of powdered metal 18 is injected into the second melt pool and allowed to cool to increase the size of the first protrusion 36. This process may be repeated until the first protrusion 36 has a desired size. The heat used to produce the second melt pool causes the first protrusion 36 to have a second

microstructure. In some embodiments, the first microstructure is equal to the second microstructure.

[0033] Additional protrusions 36 may be formed in the risk area 30 or any other portion 28 of the component 10 as shown in Fig. 2B. As such, any number of protrusions 36 may be formed, each having a specific size independent of the other protrusions 36. In some embodiments, the individual protrusions 36 are located to within a couple thousandths of an inch. In some embodiments, the light source 22 on and off times are specified in milliseconds. In some embodiments, the location of the protrusions 36 are specifically sequenced to limit the heat input to the component 10 and the build 42.

[0034] After the protrusions 36 are formed in the risk area 30 of the component, a known process of forming the build layer 16 is performed. The build layer 16 is formed by the light source 22 forming the melt pools 14 over the entire surface of the first portion 28, including the protrusions 36. Powdered metal 18 is injected into the melt pools 14. The melt pools 14 are allowed to cool and the build layer 16, integrated with the component 10, is formed. Additionally the protrusions 36 may be formed at the risk areas 30 of the component 10 on top of the build layer 16. An additional build layer 16 may then be formed using the technique previously described. These steps may be repeated until the overall build 42 is formed on the first portion 28 of the component 10. The overall build 42 has a desired third microstructure and geometry as shown in Fig. 4. The component 10 of Fig. 4 has build layers 16 that build out past the edge and the corner 38 such that the geometry of the build 42 is the desired geometry and microstructure.

[0035] The desired third microstructure and geometry are a result of the forming the protrusions as techniques that do not include the protrusions 36 result in either or both undesired geometry or microstructure. In some embodiments, the third microstructure is about equal to the first and/or second microstructures. In some embodiments, the third microstructure is about equal to the microstructure of the component 10.

[0036] This technique should not be confused with different types of metal transfer associated with arc welding processes, such as Metal Inert Gas (MIG) welding, as the disclosed technique focuses on placing very discrete protrusions 36 of the laser deposition material at specific locations with extremely short pulses of the

light source 22 and in a specific sequence. In the area of gas turbine engine components and, more particularly, in the case of the airfoil and blade repairs, the disclosed technique is used to build out the tip corners. For example, a specified draft angle from the tip corner may be used to account for overbuild to allow enough material clean up back to the original blade contour. For example, the specified draft angle is about 15 degrees. To ensure the build-out is sufficient to maintain the angle, adding the protrusion to additional material before the layer deposition may be necessary.

[0037] In one example, deposition material 18 is a powdered metal. In another example, deposition material 18 is a wire. In still yet another example, deposition material 18 is a ribbon of metal.

[0038] While the disclosure has been illustrated and described in detail in the foregoing drawings and description, the same is to be considered as exemplary and not restrictive in character, it being understood that only illustrative embodiments thereof have been shown and described and that all changes and modifications that come within the spirit of the disclosure are desired to be protected.

CLAIMS:

1. A method of applying a laser metal formed build layer on a surface of an article, the method comprising the operations of

- surveying a first portion of an article to form a build layer thereon using a laser deposition process,
- identifying an area of the first portion with an increased risk of forming the build layer with at least one of an undesirable geometry and microstructure as a result of undergoing the laser deposition process,
- determining a first location for forming a first protrusion within the identified area,
- melting the article at the first location using a power source to establish a first melt pool,
- injecting deposition material into the first melt pool,
- solidifying the first melt pool to form the first protrusion, the first protrusion having a first microstructure,
- determining a second location for forming a second protrusion within the identified area,
- melting the article at the second location using a power source to establish a second melt pool,
- injecting deposition material into the second melt pool, and
- solidifying the second melt pool to form the second protrusion, the second protrusion having the first microstructure,
- melting the first portion of the article, including the first protrusion and the second protrusion, using the power source to establish a number of melt pools,
- injecting deposition material into the number of melt pools, and
- solidifying the number of melt pools to form the build layer on the first portion of the article, the build layer having a desired geometry and a second microstructure.

2. The method of claim 1 further comprising the steps of

melting the first protrusion using the power source to establish a second melt pool,

injecting deposition material into the second melt pool, and
solidifying the second melt pool to increase the size of the first protrusion, the first protrusion retaining the first microstructure.

3. The method of claim 1, wherein the second microstructure is substantially the same as the first microstructure.

4. The method of claim 1, wherein melting the first portion of the article, including the first protrusion, using the power source to establish a number of melt pools is performed by a continuous power source.

5. The method of claim 1, wherein melting the article at the first location using a power source to establish a first melt pool is performed by a pulsing power source.

6. The method of claim 1, wherein melting the first portion of the article, including the first protrusion, using the power source to establish a number of melt pools is performed by a continuous power source.

7. The method of claim 6, wherein melting the article at the first location using a power source to establish a first melt pool is performed by a pulsing power source.

8. The method of claim 1, wherein the area of the first portion with an increased risk of forming the build layer with at least one of an undesirable geometry and microstructure as a result of undergoing the laser deposition process includes at least one of an edge and a corner of the article.

9. The method of claim 1, wherein melting the first portion of the article, including the first protrusion, using the power source to establish a number of melt pools is performed by a continuous power source.

10. The method of claim 8, wherein melting the article at the first location using a power source to establish a first melt pool is performed by a pulsing power source.

11. The method of claim 1, wherein melting the first portion of the article, including the first protrusion, using the power source to establish a number of melt pools is performed by a continuous power source.

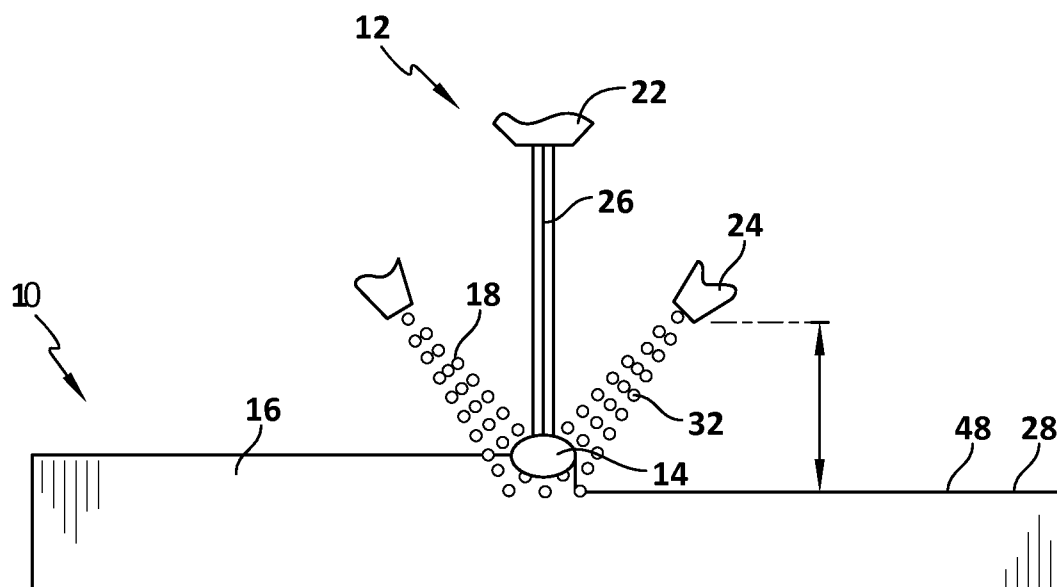
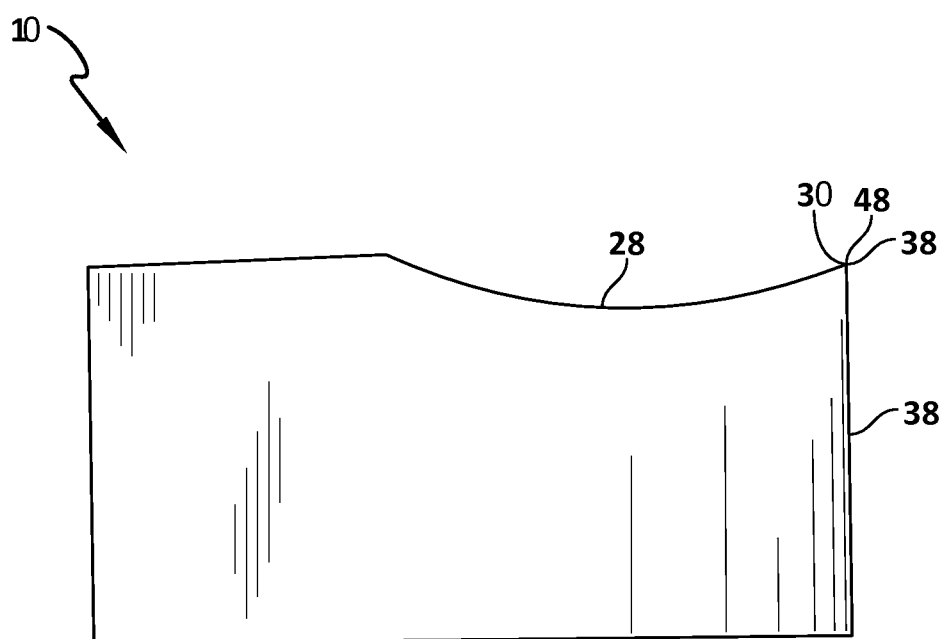
12. The method of claim 11, wherein melting the article at the first location using a power source to establish a first melt pool is performed by a pulsing power source.

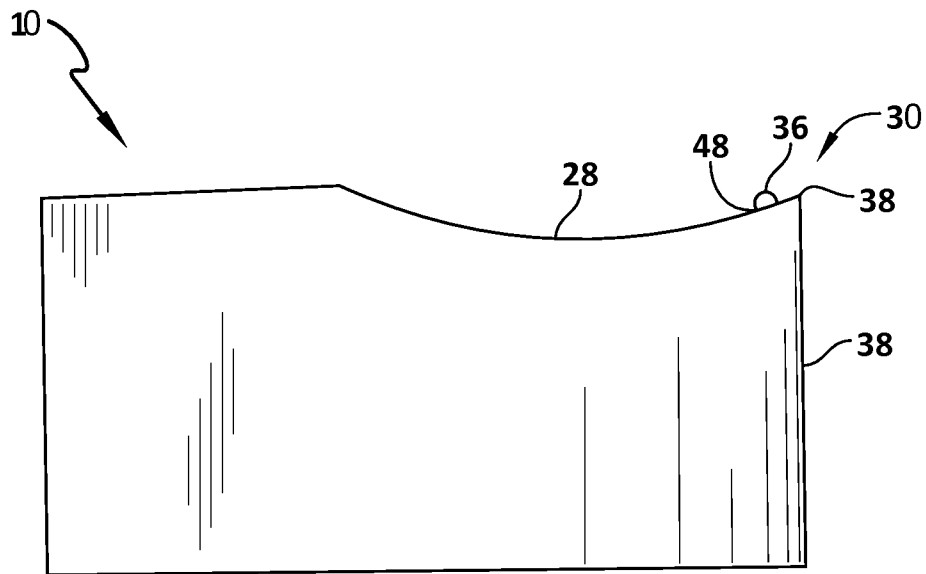
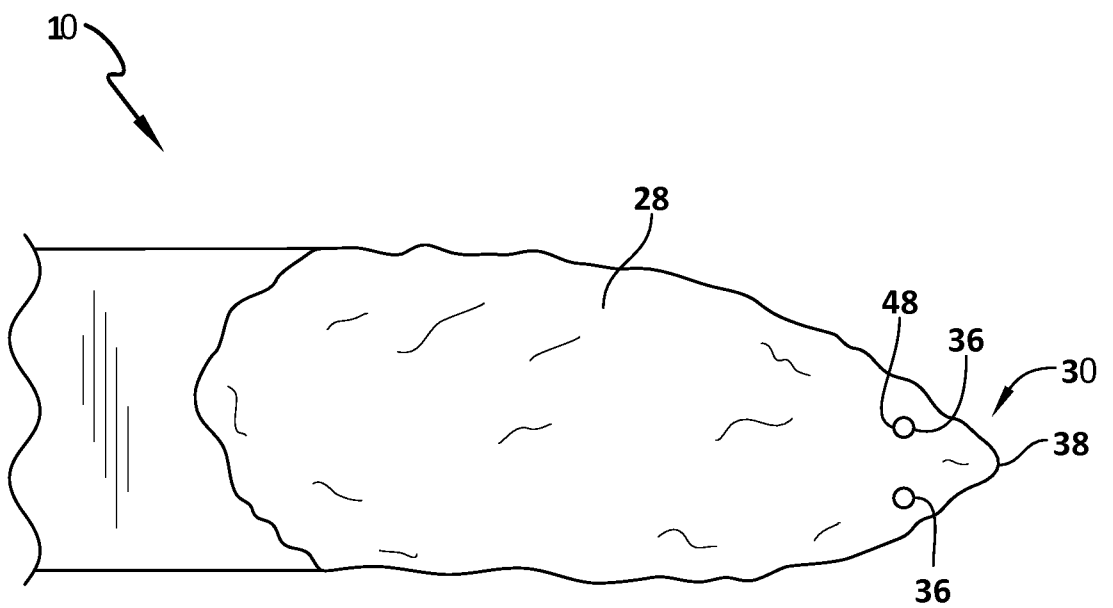
13. The method of claim 12, wherein melting the article at the second location using a power source to establish a second melt pool is performed by a pulsing power source.

14. The method of claim 13, wherein the pulsing power source turns off and on at specific time intervals.

15. The method of claim 14, wherein the pulsing power source increases and decreases in intensity at specific time intervals.

16. The method of claim 1 further comprising forming a third protrusion within the identified area of the article on top of the build layer and forming an additional build layer by repeating the steps previously described until an overall build layer is formed on the first portion of the article that has a third microstructure.

*FIG. 1**FIG. 2*

*FIG. 2A**FIG. 2B*

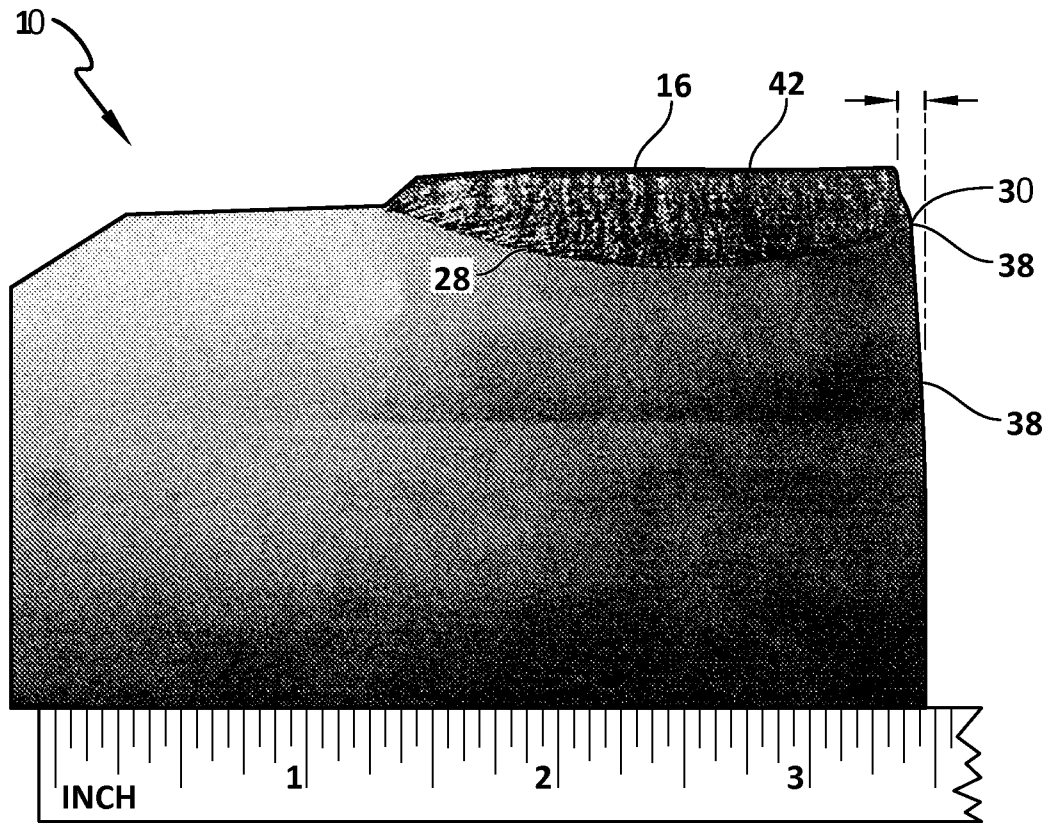


FIG. 3 (Prior Art)

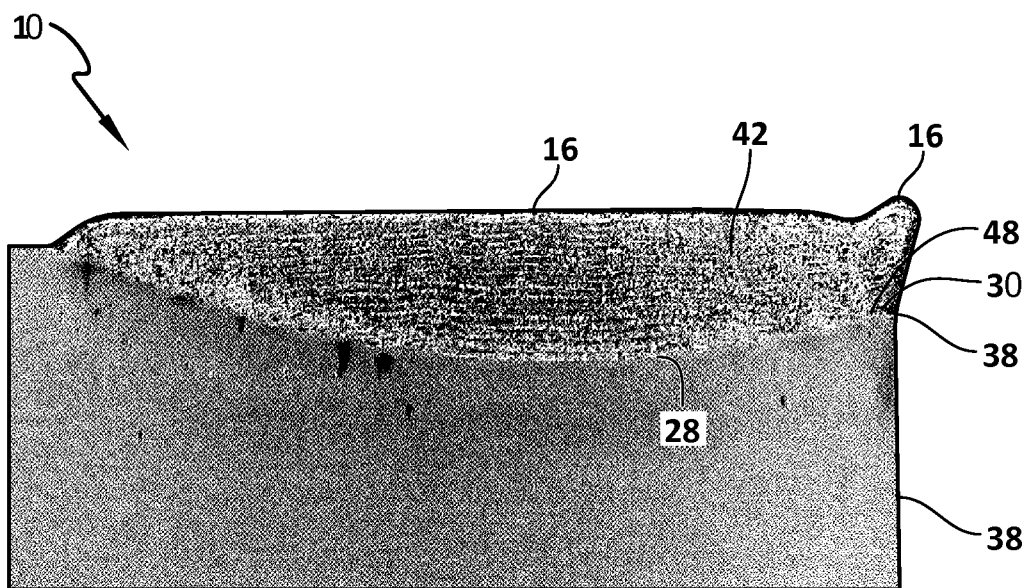


FIG. 4

