[0018] U.S. Pat. No. 5,433,820 describes a surface treatment process using electrical discharge or plasma at atmospheric pressure from a high voltage (1 kV to 50 kV) electrode. The electrode is placed in the proximity of the substrate rather than in a remote chamber. The free electrons emitted from the electrodes produce reactive hydrogen radicals --a plasma containing atomic hydrogen-- which then pass through openings in a dielectric shield placed over the oxidized substrate. The dielectric shield concentrates the active hydrogen onto those specific surface locations requiring de-oxidation. However, such dielectric shields can accumulate surface charge that may alter the electric field and inhibit precise process control. The described process is only used to flux base metal surfaces.

[0019] Accordingly, there is a problem in the art in providing an economical and efficient process for removing metal oxides from at least one component and/or solder surface under relatively low temperatures to avoid damage to the electronic components. There is a problem in the art in providing a process and apparatus for fluxless soldering under near ambient or atmospheric pressure conditions that avoids the expense of purchasing and maintaining vacuum equipment such as required, for example, in a plasma-based process and apparatus. There is problem in providing a fluxless soldering process and apparatus for internal or non-exposed surfaces of a substrate. Additionally, there is an additional problem in the art for providing a fluxless soldering process that does not involve one or more flammable gases.

BRIEF SUMMARY OF THE INVENTION

[0020] The present invention solves some, if not all, of the problems of the art by providing a method and apparatus for removing metal oxides from at least one component and/or solder surface without requiring a flux, expensive vacuum equipment, and/or a flammable gas environment. In one ~~aspect~~example embodiment, there is provided an apparatus for

removing metal oxides from the surface of a component comprising at least one selected from solder, metal, and combinations thereof through the emission of electrons in an ambient or non-vacuum pressure atmosphere by electron attachment comprising: a field emission apparatus comprising: a cathode having one or more protrusions and comprised of a conductive material wherein the material has a work function ranging from 2 to 5 eV; a dielectric material which surrounds at least a portion of the cathode; and an anode comprised of a conductive material which surrounds at least a portion of the dielectric material, wherein the cathode and anode are each connected to an electrical voltage source, and wherein the dielectric material between the cathode and anode is polarized wherein the dielectric material confines the electric field distribution and enhances the strength of the electric field near the one or more of the protrusions of the cathode and thereby emit electrons from the cathode. In this or other embodiments, at least a portion of the electrons are generated by one or more of the following processes: field emission, thermal-field emission, corona discharge, or combinations thereof.

[0021] In yet another ~~aspect~~example embodiment, there is provided an apparatus for removing metal oxides on at least one surface of a component comprising solder and metal oxides thereupon, the apparatus comprising: an field emission apparatus comprising: a cathode having one or more protrusions having a high curvature surface and comprised of a conductive material wherein the material has a work function ranging from 2 to 5 eV; a dielectric material which surrounds at least a portion of the cathode; and an anode comprised of a conductive material which surrounds at least a portion of the dielectric material wherein the cathode and anode are each connected to an electrical voltage source, and wherein the dielectric material between the cathode and anode is polarized, and provides an electric field at one or more of the protrusions of the cathode and thereby generate electrons from the cathode; a reducing gas wherein the electrons attach to at least a

portion of the reducing gas to form anions; an insulating plate comprised of a plurality of openings wherein the component is set thereupon and is proximal to the field emission apparatus; and a conductive surface which is in contact with the bottom surface of the insulating plate and preferentially has an electric potential slightly more positive than that of the anode (e.g. 10V to 1KV higher in voltage) to attract the anions towards the insulating plate and wherein the anions remove the metal oxides on the surface and then pass through the openings of the insulating plate towards the conductive surface.

[0021A] In accordance with one aspect, there is provided an apparatus for emitting electrons in an ambient pressure condition, the apparatus comprising: a cathode having one or more protrusions having a high curvature surface and comprised of a conductive material wherein the material has a work function ranging from 2 to 5 eV; a dielectric material which surrounds at least a portion of the cathode; an anode comprised of a conductive material which surrounds at least a portion of the dielectric material; and a reducing gas, wherein the cathode and anode are each connected to an electrical voltage source, and wherein the dielectric material between the cathode and anode is polarized to provide an electric field at one or more of the protrusions of the cathode and thereby generate electrons from the cathode, and wherein the electrons attach to at least a portion of the reducing gas molecules to form negatively charged atomic ions of the reducing gas.

[0021B] In accordance with another aspect, there is provided an apparatus for removing metal oxides on at least one surface of a component comprising solder and metal surfaces thereupon, the apparatus comprising: an electron emission apparatus comprising: a cathode having one or more protrusions having a high curvature surface and comprised of a conductive material wherein the material has a work function ranging from 2 to 5 eV; a dielectric material which surrounds at least a portion of the cathode; and an anode comprised of a conductive material which surrounds at least a portion of the dielectric material, wherein the cathode and anode are each connected to an electrical voltage source, and wherein the dielectric material between the cathode and anode is polarized to provide

an electric field at one or more of the protrusions of the cathode and thereby generate electrons from the cathode; a reducing gas wherein the electrons attach to at least a portion of the reducing gas molecules to form negatively charged atomic ions of the reducing gas; an insulating plate comprised of a plurality of openings wherein the component is set thereupon and is proximal to the field emission apparatus; a conductive surface having an electrical potential which is at least slightly more positive than that of the anode of the electron emission apparatus wherein the insulating plate is placed thereupon and wherein the negatively charged atomic ions of the reducing gas are attracted towards the insulating surface and remove the metal oxides on the at least one surface of the component and are discharged upon reaching the conductive surface.

[0022] These and other aspects of the invention will become apparent from the following detailed description.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0023] Figure 1 provides an example of an embodiment of the field emission apparatus described herein and a test arrangement.

[0024] Figure 2 provides an example of an embodiment of the field emission apparatus described herein wherein the field emitter comprises a cathode comprised of a plurality of needles.

[0025] Figure 3 provides an additional example of an embodiment of the field emission apparatus described and a test arrangement to observe the reduction of metal oxides on a sample.

[0026] Figure 4 provides an additional example of an embodiment of the field emission apparatus described herein.

[0027] Figure 5 provides an example of an embodiment of the apparatus described herein for treating non-exposed and non-grounded soldering surfaces.