

CLAIMS

1. An electrosurgical instrument, comprising:
an elongate probe comprising a coaxial cable for conveying
5 radiofrequency (RF) and/or microwave frequency electromagnetic (EM) energy, and
a probe tip connected at the distal end of the coaxial cable for receiving the RF
and/or microwave energy;
a gas passage for conveying gas through the elongate probe to the probe tip;
and
10 a debriding apparatus for debriding biological tissue,
wherein the coaxial cable comprises an inner conductor, an outer conductor
and a dielectric material separating the inner conductor from the outer conductor,
wherein the probe tip comprises a first electrode connected to the inner
conductor of the coaxial cable and a second electrode connected to the outer
15 conductor of the coaxial cable, and
wherein the first electrode and the second electrode are arranged to produce
an electric field from the received RF and/or microwave frequency EM energy across
a flow path of gas received from the gas passage to produce a thermal or non-
thermal plasma in an area outward from the probe tip.
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2. An electrosurgical instrument according to claim 1, wherein the first
electrode and the second electrode are movable relative to each other into a second
configuration in which the first electrode extends distally beyond the second
electrode to form a radiating structure for emitting a microwave EM field outwardly
25 from the probe tip.
3. An electrosurgical instrument according to any preceding claim,
wherein the debriding apparatus comprises an abrasive region on a distal outer
surface of the probe tip for debriding biological tissue at the probe tip.
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4. An electrosurgical instrument according to any preceding claim,
wherein the debriding apparatus comprises a debriding tool, and wherein the probe
tip comprises a holder for receiving the debriding tool, the debriding tool being
moveable between a stowed position, in which the debriding tool is enclosed within
35 the holder, and a deployed position, in which the debriding tool protrudes into the
area outward from the probe tip for debriding biological tissue.
5. An electrosurgical instrument according to any preceding claim,
wherein the elongate probe comprises a sleeve surrounding the coaxial cable, the

gas passage being a space between an inside surface of the sleeve and an outside surface of the coaxial cable.

5 6. An electrosurgical instrument according to claim 5, wherein the second electrode is formed on the distal end of the sleeve, and the sleeve is retractable relative to the coaxial cable.

10 7. An electrosurgical instrument according to claim 5 or 6, wherein the sleeve comprises a rotatable braided cable to permit adjustment of an orientation of the debriding apparatus.

15 8. An electrosurgical instrument according to any preceding claim, wherein the debriding apparatus comprises a liquid passage for conveying liquid through the elongate probe and into or out of the area outward of the probe tip for debriding biological tissue.

20 9. An electrosurgical instrument according to claim 8, when dependent on any one of claims 5-7, wherein the elongate probe comprises a jacket surrounding the sleeve, the liquid passage being a space between the inside surface of the jacket and an outside surface of the sleeve.

25 10. An electrosurgical instrument according to claim 8, when dependent on any one of claims 5-7, wherein the space between the inside surface of the sleeve and the outside surface of the coaxial cable is partitioned into the gas passage and the liquid passage.

30 11. An electrosurgical instrument according to any one of claims 8 to 10, wherein the liquid passage is partitioned into a first channel for conveying liquid through the elongate probe into the area outward of the probe tip, and a second channel for conveying liquid through the elongate probe out of the area outward of the probe tip.

35 12. An electrosurgical instrument according to any preceding claim, wherein the first electrode is a radiating microwave monopole antenna structure coupled to receive RF and/or microwave EM energy from the coaxial cable.

40 13. An electrosurgical instrument according to any preceding claim, wherein the first electrode and the second electrode form active and return electrodes for an RF signal conveyed by the coaxial cable.

14. An electrosurgical instrument according to any preceding claim, wherein the outer electrode of the coaxial cable is connected to the second electrode by a gas permeable conductive structure that is slidable relative to the second electrode or outer electrode of the coaxial cable and permits gas to flow through it.

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15. An electrosurgical instrument according to any preceding claim, wherein the probe is insertable through the instrument channel of a scoping device.

16. Electrosurgical apparatus comprising:
a radiofrequency (RF) signal generator for generating RF electromagnetic (EM) radiation having a first frequency;
a microwave signal generator for generating microwave EM radiation having a second frequency that is higher than the first frequency;
an electrosurgical instrument according to any preceding claim connected to receive the RF EM radiation and the microwave EM radiation;
a feed structure for conveying the RF EM radiation and the microwave EM radiation to the elongate probe, the feed structure comprising an RF channel for connecting the elongate probe to the RF signal generator, and a microwave channel for connecting the elongate probe to the microwave signal generator,
a gas feed connected to supply gas to the electrosurgical instrument, wherein the apparatus is operable to debride biological tissue in the area outward from the probe tip, and
wherein the apparatus is operable to deliver a thermal or non-thermal plasma in the area outward from the probe tip.

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17. Electrosurgical apparatus according to claim 16, when dependent on claim 8, comprising:

a liquid feed connected to supply liquid to, or extract liquid from, the electrosurgical instrument,

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wherein the apparatus is operable to supply liquid to, or extract liquid from, the area outward from the probe tip for debriding biological tissue.

18. Electrosurgical apparatus according to claim 17, when dependent on claim 11, wherein the liquid feed comprises:

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an injection device for supplying liquid to the electrosurgical instrument via the first channel, and

a suction device for extracting liquid from the electrosurgical instrument via the second channel.

19. Electrosurgical apparatus according to any one of claims 16 to 18, wherein the first electrode and the second electrode are movable relative to each other into a second configuration in which the first electrode extends distally beyond the second electrode to form a radiating structure for emitting a microwave EM field outwardly from the probe tip, and

wherein the apparatus is operable to emit a non-ionising electric field outwardly from the probe tip when the first electrode and the second electrode are in the second configuration without gas supplied to thereto.

20. Electrosurgical apparatus according to any one of claims 16 to 19, comprising a strike signal generation circuit arranged to cause a pulse of RF EM energy to be delivered to the probe to generate the high electric field across the flow path for striking the plasma, wherein the strike signal generation circuit includes control circuitry arranged to use a detectable characteristic of a pulse of microwave EM energy on the microwave channel to trigger generation of the pulse of RF EM energy.

21. Electrosurgical apparatus according to any one of claims 16 to 20 comprising:

a microwave signal detector for sampling forward and reflected power on the microwave channel and generating therefrom a microwave detection signal indicative of the microwave power delivered by the probe; and

a controller in communication with the microwave signal detector to receive the microwave detection signal,

wherein the controller is operable to select a first energy delivery profile for the microwave EM energy, the first energy delivery profile for the microwave EM energy being for sterilization of tissue,

wherein the controller comprises a digital microprocessor programmed to output a first microwave control signal for the microwave signal generator, the first microwave control signal being for setting the first energy delivery profile for the microwave EM energy, and

wherein the controller is arranged to determine a state for the first microwave control signal based on the received microwave detection signal.

22. Electrosurgical apparatus according to claim 21, wherein the controller is operable to select a second energy delivery profile for the microwave EM energy, the second energy delivery profile for the microwave EM energy being for resurfacing of tissue,

wherein the digital microprocessor is programmed to output a second microwave control signal for the microwave signal generator, the second microwave

control signal being for setting the second energy delivery profile for the microwave EM energy.

5 23. Electrosurgical apparatus according to claim 21 or 22 including a movement mechanism for causing relative movement between the first electrode and second electrode, wherein the controller is arranged to communicate a control signal to the movement mechanism based on the received microwave detection signal.

10 24. Electrosurgical apparatus according to claim 23, wherein the movement mechanism comprises any one of a linear motor, a stepper motor, a piezoelectric actuator, and a magnetostrictive actuator.

15 25. Electrosurgical apparatus according to any one of claims 21 to 24, when dependent on claim 4, comprising a deployment mechanism for causing relative movement between the debridging tool and the holder, wherein the controller is arranged to communicate a debridging signal to the deployment mechanism for moving the debridging tool between the stowed and deployed positions.

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