

CLAIMS

1. An electrosurgical apparatus for treating biological tissue with microwave energy, the apparatus comprising:

5 a microwave energy signal generator for generating a microwave energy waveform;

an electrosurgical instrument arranged to deliver the microwave energy waveform from a distal end thereof for tissue treatment;

a controller in communication with the microwave energy signal generator;

10 the microwave energy signal generator being configured to deliver the microwave energy waveform as one microwave energy signal pulse, and

the controller being configured to control the profile of the one microwave energy signal pulse to cause ablation or coagulation of the biological tissue and to substantially prevent the one pulse from causing heat to build-up in the

15 electrosurgical instrument.

2. The electrosurgical apparatus of claim 1, wherein the controller is configured to control the profile of the one pulse such that an energy of the one microwave energy signal pulse is maintained at or above an energy minimum which

20 is set to cause ablation or coagulation of the biological tissue during the one microwave energy signal pulse.

3. The electrosurgical apparatus of claim 2, wherein the energy minimum is 1 kJ.

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4. The electrosurgical apparatus of any preceding claim, wherein the controller is configured to control the profile of the one pulse such that a peak power of the one pulse is maintained at or above a peak power minimum which is set to cause ablation or coagulation of the biological tissue during the one microwave

30 energy signal pulse.

5. The electrosurgical apparatus of claim 4, wherein the peak power minimum is any one of the following 1 kW, 10 kW, 1 MW, 5 MW.

6. The electrosurgical apparatus of any preceding claim, wherein the controller is configured to control the profile of the one pulse such that a duration of an ON portion of the one pulse is maintained at or below an ON portion duration limit which is set to substantially prevent the microwave energy waveform from causing dielectric heating of the electrosurgical instrument during the one pulse.

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7. The electrosurgical apparatus of claim 6, wherein the ON portion duration limit is any one of the following: 1 s, 0.1 s, 1 ms, 0.2ms.

8. The electrosurgical apparatus of any preceding claim, wherein the controller is configured to control the profile of the one pulse such that a duty cycle of the one pulse is maintained at or below a duty cycle limit which is set such that heat which the microwave energy waveform causes to be built up in the electrosurgical instrument during an ON portion of the one pulse substantially dissipates during an OFF portion of the one pulse.

9. The electrosurgical apparatus of claim 8, wherein at least one of the following applies:

- (a) the duty cycle limit is 10%,
- (b) the ON portion has a duration of between 10 μ s to 200 μ s.

10. The electrosurgical apparatus of any preceding claim, when dependent on claim 2, wherein:

the microwave energy signal generator is configured to deliver the microwave energy waveform as a plurality of microwave energy signal pulses, and

the controller is configured to control the profile of the plurality of microwave energy signal pulses to form a plurality of bursts of pulses, wherein an energy of each burst is maintained at or above the energy minimum.

11. The electrosurgical apparatus of claim 10, wherein at least one of the following applies:

- (a) each burst has a burst duty cycle of up to 40%,
- (b) each burst has a burst ON portion duration of up to 200 ms.

12. The electrosurgical apparatus of any preceding claim, wherein the electrosurgical instrument comprises:

a coaxial cable for conveying the microwave energy waveform, the coaxial cable having an inner conductor, an outer conductor, and a first dielectric material separating the inner conductor and the outer conductor; and

a radiating tip portion disposed at a distal end of the coaxial cable to receive the microwave energy waveform from the coaxial cable and to radiate a localized microwave field for tissue treatment.

13. The electrosurgical apparatus of claim 12, wherein the radiating tip portion comprises:

a dielectric tip, and

a distal conductive portion of the inner conductor, which extends longitudinally into the dielectric tip.

5 14. The electrosurgical apparatus according to claim 13, wherein the outer diameter of the coaxial cable and radiating tip portion is equal to or less than 2.5 mm.

10 15. The electrosurgical apparatus of claim 12, wherein the radiating tip portion comprises two conductive elements separated by an insulator, and wherein one conductive element is connected to the inner conductor of the coaxial cable and the other conductive element is connected to the outer conductor of the coaxial cable.

15 16. The electrosurgical apparatus of claim 12, wherein the radiating tip portion comprises a helical antenna.

 17. The electrosurgical apparatus of any of claims 12 to 16, wherein the radiating tip portion is arranged to act as a quarter wave impedance transformer to match an input impedance to a tissue load impedance.

20 18. A method of controlling microwave energy delivered from an electrosurgical instrument into a biological tissue at the distal end of the electrosurgical instrument, the method comprising:
 generating a microwave energy waveform;
 conveying the microwave energy waveform along a microwave channel to the
25 electrosurgical instrument;
 delivering the microwave energy waveform into biological tissue from the distal end of the electrosurgical instrument as one or more microwave energy signal pulses;
 controlling the profile of the one or more microwave energy signal pulses to
30 cause ablation or coagulation of the biological tissue and to substantially prevent the or each pulse from causing heat to build-up in the electrosurgical instrument.

 19. The method of claim 18, wherein the step of controlling further comprises:
35 controlling the profile of the or each pulse such that an energy of the one or more microwave energy signal pulses is maintained at or above an energy minimum which is set to cause ablation or coagulation of the biological tissue during the one or more microwave energy signal pulses.

40 20. The method of claim 19, wherein the energy minimum is 1 kJ.

21. The method of any one of claims 18 to 20, wherein the step of controlling further comprises:

controlling the profile of the or each pulse such that a peak power of the or each pulse is maintained at or above a peak power minimum which is set to cause ablation or coagulation of the biological tissue during the or each pulse.

22. The electrosurgical apparatus of claim 21, wherein the peak power minimum is any one of the following 1 kW, 10 kW, 1 MW, 5 MW.

23. The method of any one of claims 18 to 22, wherein the step of controlling further comprises:

controlling the profile of the or each pulse such that a duration of an ON portion of the or each pulse is maintained at or below an ON portion duration limit which is set to substantially prevent the microwave energy waveform from causing dielectric heating of the electrosurgical instrument during the or each pulse.

24. The method of claim 23, wherein the ON portion duration limit is any one of the following: 1 s, 0.1 s, 1 ms, 0.2 ms.

25. The method of any one of claims 18 to 24, wherein the step of controlling further comprises:

controlling the profile of the or each pulse such that a duty cycle of the or each pulse is maintained at or below a duty cycle limit which is set such that heat which the microwave energy waveform causes to be built up in the electrosurgical instrument during an ON portion of that pulse is substantially dissipated during an OFF portion of that pulse.

26. The method of claim 25, wherein at least one of the following applies:

- (a) the duty cycle limit is 10%,
- (b) the ON portion has a duration of between 10 μ s to 200 μ s.

27. The method of any one of claims 18 to 26, when dependent on claim 19, wherein the step of delivering comprises delivering the microwave energy waveform from the distal end of the electrosurgical instrument as a plurality of microwave energy signal pulses, and

wherein the step of controlling comprises controlling the profile of the plurality of microwave energy signal pulses to form a plurality of bursts of pulses, wherein an energy of each burst is maintained at or above the energy minimum.

28. The method of claim 27, wherein at least one of the following applies:

- (a) each burst has a burst duty cycle of up to 40%,
- (b) each burst has a burst ON portion duration of up to 200 ms.

5 29. The method of any of claims 18 to 28, further comprising:
inserting the electrosurgical instrument through the lumen of a patient's blood
vessel to a junction between the blood vessel and a tumour.

10 30. The method of claim 29, further comprising:
cutting off a blood supply to the tumour by ablating or coagulating biological
tissue at the junction using the microwave energy waveform.

15 31. The method of claim 29 or 30, further comprising:
forming a plug in the tumour at an opening between the tumour and the blood
vessel by ablating or coagulating biological tissue at the opening using the
microwave energy waveform, and
detaching the tumour from the blood vessel by ablating or coagulating
biological tissue at the junction using the microwave energy waveform.

20 32. The method of any of claims 29 to 31, further comprising:
inserting the electrosurgical instrument through the junction and inside the
tumour; and
ablating or coagulating biological tissue inside the tumour using the
microwave energy waveform.

25 33. The method of any of claims 29 to 32, further comprising:
inserting a catheter through the lumen of the patient's blood vessel to the
junction between the blood vessel and the tumour;
inserting the electrosurgical instrument through the catheter.

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