

CLAIMS

What is claimed is:

1. A transformer comprising:
a primary coil comprising
5 a first shield of a first coaxial cable,
a second shield of a second coaxial cable, and
a conductive interconnector connecting the first shield to the second
shield; and
a secondary coil comprising
10 a first core of the first coaxial cable,
a second core of the second coaxial cable, and
a pair of conductive lines connecting the first core to the second core.
2. The transformer of claim 1, wherein the first coaxial cable extends parallel to the
second coaxial cable.
- 15 3. The transformer of claim 1, wherein a sum of lengths of the first core, the second
core and the pair of conductive lines is at least one of based or equal to a multiple of a
length of each of the first coaxial cable and the second coaxial cable.
4. The transformer of claim 1, wherein a length of each of the first coaxial cable and
the second coaxial cable is at least one of based on or equal to a fraction multiple of a
20 wavelength of a radio frequency signal transmitted by the transformer.
5. A radio frequency distribution circuit comprising:
a radio frequency generator to generate a first radio frequency signal including a
frequency component at a radio frequency; and
the transformer of claim 1, wherein the transformer is to convert the first radio
25 frequency signal to a second radio frequency signal, the second radio frequency signal
includes a frequency component at the first radio frequency.
6. A substrate processing system comprising:
the radio frequency distribution circuit of claim 5;

a process chamber;
a showerhead comprising an electrode and implemented in the process chamber; and
a substrate support implemented in the process chamber adjacent the showerhead,
5 wherein the transformer is to supply the second radio frequency signal to the electrode.

7. A radio frequency distribution circuit comprising:
a first filter to receive a first radio frequency signal and a second radio frequency
10 signal from at least one radio frequency generator and filter out the first radio frequency signal, the first radio frequency signal is at a first frequency and the second radio frequency signal is at a second frequency, and the second frequency is less than the first frequency;
a second filter to receive the first radio frequency signal and the second radio
15 frequency signal from the at least one radio frequency generator and filter out the first radio frequency signal;
a first match network to match an output of the at least one radio frequency generator to an input of the first filter;
a second match network to match an output of the at least one radio frequency
20 generator to an input of the second filter; and
a transformer coupled combiner to convert the first radio frequency signal to a third radio frequency signal, convert the second radio frequency signal to a fourth radio frequency signal, and combine either the first radio frequency signal with the second radio frequency signal or the third radio frequency signal with the fourth radio frequency
25 signal, the third radio frequency signal includes a frequency component at the first radio frequency, and the fourth radio frequency signal includes a frequency component at the second radio frequency.

8. The radio frequency distribution circuit of claim 7, wherein the transformer coupled combiner comprises:
30 a first transformer to receive an output of the first filter; and
a second transformer to receive an output of the second filter.

9. The radio frequency distribution circuit of claim 8, wherein:
the first transformer comprises
a primary coil connected to the first filter, and
a secondary coil; and
5 the second transformer comprises
a primary coil connected to the second filter and the primary coil of the
first transformer, and
a secondary coil connected to the secondary coil of the first transformer.
10. The radio frequency distribution circuit of claim 9, wherein:
10 the primary coil and the secondary coil of the first transformer are connected to a
ground reference, and
the primary coil and the secondary coil of the second transformer are connected
to the ground reference.
11. The radio frequency distribution circuit of claim 9, wherein the first transformer
15 comprises:
a primary coil comprising
a first shield of a first coaxial cable,
a second shield of a second coaxial cable, and
a conductive interconnector connecting the first shield to the second
20 shield; and
a secondary coil comprising
a first core of the first coaxial cable,
a second core of the second coaxial cable, and
a pair of conductive lines connecting the first core to the second core.
- 25 12. The radio frequency distribution circuit of claim 11, wherein the first coaxial cable
extends parallel to the second coaxial cable.
13. The radio frequency distribution circuit of claim 11, wherein a sum of lengths of
the first core, the second core and the pair of conductive lines is at least one of based
on or equal to a multiple of a length of each of the first coaxial cable and the second
30 coaxial cable.

14. The radio frequency distribution circuit of claim 11, wherein a length of each of the first coaxial cable and the second coaxial cable is at least one of based on or equal to a fraction multiple of a wavelength of the first radio frequency signal.
15. The radio frequency distribution circuit of claim 7, wherein:
5 the transformer coupled combiner comprises a first transformer; and
the first transformer comprises
a first primary coil connected to the first filter,
a second primary coil connected to the second filter,
a first secondary coil connected to receive the third radio frequency
10 signal, and
a second secondary coil connected to receive the fourth radio frequency
signal.
16. The radio frequency distribution circuit of claim 15, wherein:
the first transformer comprises a third secondary coil;
15 the third secondary coil is to receive a fifth radio frequency signal; and
the fifth radio frequency signal includes a frequency component at the first
frequency and a frequency component at the second frequency.
17. The radio frequency distribution circuit of claim 7, wherein the transformer
coupled combiner comprises:
20 a first primary coil connected to the first filter;
a second primary coil connected to the second filter;
a first secondary coil outputting the third radio frequency signal, the third radio
frequency signal includes frequency components respectively at the first radio
frequency and the second radio frequency; and
25 a second secondary coil outputting the fourth radio frequency signal, the fourth
radio frequency signal includes frequency components respectively at the first radio
frequency and the second radio frequency.

18. The radio frequency distribution circuit of claim 17, wherein the transformer coupled combiner comprises:

5 a third secondary coil outputting a fifth radio frequency signal, the fifth radio frequency signal includes frequency components respectively at the first radio frequency and the second radio frequency; and

a fourth secondary coil outputting a sixth radio frequency signal, the sixth radio frequency signal includes frequency components respectively at the first radio frequency and the second radio frequency.

19. A substrate processing system comprising:
10 the radio frequency distribution circuit of claim 7;
a process chamber;
a showerhead comprising the electrode and implemented in the process chamber; and
15 a substrate support implemented in the process chamber adjacent the showerhead.

20. A radio frequency distribution circuit to supply radio frequency power to an electrode in a substrate processing system, the radio frequency distribution circuit comprising:
a radio frequency generator to generate a first radio frequency signal;
20 a transformer to convert the first radio frequency signal to a second radio frequency signal and supply the second radio frequency signal to the electrode to adjust plasma ionization density and ionization energy within a process chamber of the substrate processing system; and
a match network to match an output of the radio frequency generator to an input
25 of the transformer.