Claims

1. A broadband microwave heating apparatus, comprising:

an applicator cavity for exposing a workpiece to microwave energy;

a microwave power supply connected to the cavity, the power supply comprising:

a small-signal RF source comprising at least a voltage controlled microwave oscillator and a voltage controlled attenuator that are both thermally stabilized at a selected temperature above ambient;

a two port microwave amplifier to amplify a signal from the small-signal RF source to a usable power level for heating;

forward and reflected power detectors, the detectors separated from one another by a microwave isolator, wherein the forward power detector is located upstream of the microwave isolator;

a power regulator configured to determine a difference between a forward power detected by the forward power detector and a power setting of the microwave power supply; and

a control system including a power control loop and configured to use an output of the power regulator to adjust an output power of the microwave power supply based on the determined difference between the forward power detected by the forward power detector and the power setting of the microwave power supply,

a heater; at least one of a temperature sensor or a thermostat; wherein all of the small-signal RF source are mounted on a common thermal platform and maintained at a common temperature above an ambient temperature, wherein the heater is controlled by the at least one of a temperature sensor or the thermostat.

2. The apparatus of claim 1, wherein the small-signal RF source further includes a fixed attenuator and a bandpass filter.

3. The apparatus of claim 1, wherein the forward and reflected power detectors are thermally stabilized at a selected temperature above ambient.

4. A broadband microwave power supply, comprising:

a small-signal RF source comprising at least a voltage controlled microwave oscillator (VCO) and a voltage controlled attenuator (VCA) that are both thermally stabilized at a selected temperature above ambient;

a microwave amplifier to amplify a signal from the small-signal RF source to a usable power level for heating;

forward and reflected power detectors, the detectors separated from one another by a microwave isolator, wherein the forward power detector is located upstream of the microwave isolator;

a power regulator configured to determine a difference between a forward power detected by the forward power detector and a power setting of the microwave power supply; and

a control system including a power control loop and configured to use an output of the power regulator to adjust an output power of the microwave power supply based on the determined difference between the forward power detected by the forward power detector and the power setting of the microwave power supply,

a heater; at least one of a temperature sensor or a thermostat; wherein all of the small-signal RF source are mounted on a common thermal platform and maintained at a common temperature above an ambient temperature, wherein the heater is controlled by the at least one of a temperature sensor or the thermostat.

5. The broadband microwave power supply of claim 4, wherein the small-signal RF source further includes a fixed attenuator and a bandpass filter.

6. The broadband microwave power supply of claim 4, wherein the forward and reflected power detectors are thermally stabilized at a selected temperature above ambient.

7. The broadband microwave power supply of claim 4, further comprising:

a heater and temperature control circuit; and,

a package containing the VCO, VCA, heater, and temperature control circuit and having external connections for DC power, DC frequency control voltage, DC amplitude control voltage, and RF signal out.

8. The broadband microwave power supply of claim 7, wherein the package comprises a printed circuit board.

9. The broadband microwave power supply of claim 7, wherein the package comprises a hybrid circuit module.

10. A method of heating materials using broadband microwave power, comprising:

placing a selected workpiece in a multi-mode microwave applicator cavity;

providing a microwave power supply in communication with the cavity, the power supply including a small-signal RF generating circuit, a microwave amplifier, and forward and reflected power detectors, the detectors separated from one another by an isolator;

heating at least some of the components of the small-signal RF generating circuit to a selected temperature above ambient, a heater; at least one of a temperature sensor or a thermostat; wherein all of the small-signal RF source are mounted on a common thermal platform and maintained at a common temperature above an ambient temperature, wherein the heater is controlled by the at least one of a temperature sensor or the thermostat;

providing a control system to perform the following functions:

run an automatic power leveling routine to automatically generate an autolevel table and download the autolevel table to the control system;

provide an automatic power control system to limit the rate of power adjustment; and,

applying microwave power into the applicator cavity under the control of the control system to heat the workpiece, wherein the control system uses a power regulator to adjust an output power of the microwave power supply based on a

comparison between a forward power detected by the forward power detector and a power setting of the microwave power supply.

11. The method of claim 10, wherein the automatic power leveling routine includes a spline-based surface fitting routine.

12. The method of claim 10, further including the step of heating the forward and reflected power detectors to a selected temperature above ambient.

13. The method of claim 10, wherein the automatic power control system further includes a limiter that prevents adjustments beyond a preset amount.

14. The method of claim 10, wherein the automatic power control system includes an alarm function to notify the master control if the system is not able to maintain accurate power control.

15. The apparatus of claim 1, wherein respective isolation amplifiers are disposed between each one of the detectors and the control system, and a crystal detector that is maintained at the common temperature above ambient is disposed between the respective isolation amplifiers and each one of the detectors.

16. The broadband microwave heating apparatus of claim 1, wherein the microwave isolator has two ports.

17. The broadband microwave power supply of claim 4, wherein the microwave isolator is a three-port directional coupler having a terminated port.