CLAIMS

1. A temperature control apparatus for supplying fluid to control a temperature of at least one semiconductor wafer within a semiconductor processing chamber, said temperature control apparatus comprising:

a mixed refrigerant refrigeration system;

said temperature control apparatus being configured to supply said mixed refrigerant to at least one conditioning circuit within said semiconductor processing chamber and to receive said mixed refrigerant from said at least one conditioning circuit; wherein

said temperature control apparatus comprises temperature control circuitry for controlling a temperature of said at least one conditioning circuit to one of a plurality of predetermined temperatures, at least one of said temperatures being below -100˚C;

said temperature control circuitry being configured to receive a signal indicative of a temperature of said at least one conditioning circuit from at least one temperature sensor and to control said temperature of said at least one conditioning circuit in dependence upon said received signal and said predetermined temperature by controlling a composition of said mixed refrigerant supplied to said at least one conditioning circuit by altering a mass flow rate of liquid phase refrigerants leaving a phase separator to change said temperature of said at least one conditioning circuit.

2. A temperature control apparatus according to any preceding claim, wherein said temperature control apparatus comprises:

said at least one temperature sensor.

3. A temperature control apparatus according to claim 1 or 2, wherein said apparatus is configured to supply said mixed refrigerant to a plurality of conditioning circuits for cooling or conditioning a plurality of semiconductor wafer, said plurality of conditioning circuits being arranged in parallel with each other,

said temperature control apparatus being configured to control circulation of said mixed refrigerant through selected ones of said plurality of conditioning circuits during a processing cycle.

4. A temperature control apparatus according to claim 3, wherein said temperature control circuitry is configured to individually control a temperature of said plurality of conditioning circuits by controlling at least one of a mass flow rate, temperature or composition of said mixed refrigerant supplied to each of said plurality of conditioning circuits.

5. A temperature control apparatus according to claim 4, wherein said temperature control circuitry is configured to receive signals indicative of a temperature of each said plurality of conditioning circuits from a plurality of temperature sensors and to control said temperature of said plurality of conditioning circuits in dependence upon said received signals and said predetermined temperatures by controlling at least one of a mass flow rate, composition or temperature of said mixed refrigerant supplied to each of said plurality of conditioning circuits.

6. A temperature control apparatus according to any preceding claim comprising:

a bypass mixed refrigerant channel for channelling a portion of said mixed refrigerant output from said compressor around at least a portion of said refrigeration system such that mixed refrigerant in said bypass channel is warmer than mixed refrigerant output by said refrigeration system; wherein

said temperature control circuitry is configured to control a temperature of said mixed refrigerant output to each of said selected ones of said plurality of conditioning circuits by controlling a supply at least one of said mixed refrigerant from said bypass channel and said mixed refrigerant output from said refrigeration system to said at least one wafer conditioning circuit.

7. A temperature control apparatus according to any preceding claim, wherein said temperature control apparatus comprises:

at least one valve for controlling a flow of refrigerant into said at least one conditioning circuit.

8. A temperature control apparatus according to claim 7, wherein said at least one valve comprises at least one of: an on/off valve and a proportional flow control valve.

9. A temperature control apparatus according to preceding claim, wherein said temperature control apparatus comprises:

a heat exchanger through which at least a portion of said mixed refrigerant flows, said heat exchanger being configured to receive a controlled flow of at least one warmer fluid from another portion of said refrigerant system.

10. A temperature control apparatus according to any preceding claim, wherein said temperature control apparatus comprises:

an expansion device for controlling an expansion of said mixed refrigerant and thus, a pressure and temperature of said mixed refrigerant within said at least one conditioning circuit.

11. A temperature control apparatus according to any preceding claim, wherein said refrigeration system comprises at least one compressor, said temperature control circuitry comprising control circuitry for controlling a discharge mass flow rate of said at least one compressor.

12. A temperature control apparatus according to claim 11, wherein said refrigeration system comprises a plurality of compressors arranged in parallel, said temperature control circuitry comprising control circuitry for controlling a discharge mass flow rate of said plurality of compressors by controlling at least one of:

a number of said plurality of compressors that are operational;

a control speed of at least one of said plurality of compressors; and

unloading at least one of said plurality of compressors.

13. An apparatus comprising a semiconductor processing chamber comprising at least one conditioning circuit, and a temperature control apparatus according to any preceding claim, said temperature control apparatus being arranged such that mixed refrigerant from said temperature control apparatus is supplied to said at least one conditioning circuit.

14. A method of controlling a temperature of at least one semiconductor wafer within a semiconductor processing chamber by controlling a temperature of at least one conditioning circuit within said semiconductor processing chamber to one of a plurality of predetermined temperatures, at least one of said temperatures being below -100°C; said method comprising:

supplying a mixed refrigerant from a refrigeration system to said at least one conditioning circuit within said semiconductor processing chamber;

receiving said mixed refrigerant from said at least one conditioning circuit; and

receiving a signal indicative of a temperature of said at least one conditioning circuit from at least one temperature sensor and in dependence upon said received signal and said predetermined temperature controlling said temperature by controlling a composition of said mixed refrigerant supplied to said at least one conditioning circuit by altering a mass flow rate of liquid phase refrigerants leaving a phase separator to change said temperature of said at least one conditioning circuit.