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(54) **FLEXIBLE MODULAR HIERARCHICAL ADAPTIVELY CONTROLLED ELECTRONIC-SYSTEM COOLING AND ENERGY HARVESTING FOR IC CHIP PACKAGING, PRINTED CIRCUIT BOARDS, SUBSYSTEMS, CAGES, RACKS, IT ROOMS, AND DATA CENTERS USING QUANTUM AND CLASSICAL THERMOELECTRIC MATERIALS**

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(57) **ABSTRACT**
A system for adaptive cooling and energy harvesting comprising at least one thermoelectric device capable of acting as a thermoelectric cooler and as a thermoelectric generator, a hierarchical multiple-level control system, and electronics controlled by the control system and connected to the thermoelectric device. The electronics selectively configure the thermoelectric device in at least in a thermoelectric cooler operating mode and in a thermoelectric generation operating mode. The thermoelectric device can incorporate quantum-process and quantum-well materials for higher heat transfer and thermoelectric generation efficiencies. The invention provides for thermoelectric devices to additionally operate in temperature sensing mode. The hierarchical control system can comprise a plurality of control system, each of which can operate in isolation and can be interconnected with additional subsystems associated with other hierarchical levels. The hierarchical control system can comprise linear (additive) control, bilinear (additive and multiplicative) control, nonlinear control, and hysteresis.

