902 supporting two of dual column transportable wafer racks 300. In such an example, a method of loading the transportable wafer racks may include loading a first one of the racks adjacent load station 116 and then rotating the turntable approximately 180 degrees and loading the second rack, and then closing valves 122 and 124 and purging and drawing vacuum in the load lock chamber.

[0038] VTM

[0039] FIG. 10 illustrates one example of an interior chamber 1002 of VTM 102. In the illustrated example, VTM 102 includes a robotic arm 1004 that is configured to move transportable wafer racks, such as wafer racks 200 and 300, throughout the system. In the illustrated example, robotic arm 1004 includes a pivotable shoulder, a first arm segment, a pivotable elbow, a second arm segment, a pivotable wrist, and an end effector 1006. FIG. 10 shows one of wafer racks 300 loaded with a plurality of wafers positioned on end effector 1006. As noted above, VTM 102 includes a plurality of openings configured to couple to various modules of system 100. FIG. 10 shows two openings 1008a, 1008b. One of preheat chambers 108 is coupled to opening 1008b and FIG. 10 shows one of heated gate valves 126b in a closed position in opening 1008b. Reactor 106 is coupled to opening 1008a and a reactor door 1010 is shown in a closed position in FIG. 10. VTM robotic arm 1004 is configured to rapidly, e.g., in less than one minute, transport wafer racks from preheat chambers 108 to reactor 106 for processing so that a temperature of the heated wafers when the wafers are deposited in the reactor is substantially the same as the temperature of the wafers in the preheat chamber.

[0040] FIG. 11 is a perspective view of VTM robot end effector 1006. As noted above, end effector 1006 is designed and configured as a universal end effector for coupling to a plurality of different transportable wafer racks, such as wafer racks 200 and 300. End effector 1006 includes a recess 1102 that has a complementary shape with respect to universal interface 204 of racks 200 and 300 (FIGS. 2 and 3) for coupling with the racks. In the illustrated example, the robotic arm 1004 is configured to couple to a base of the wafer racks and lift the wafer rack and maintain the wafer rack in a vertical position as the robotic arm moves the wafer rack throughout the system. Recess 1102 includes first and second opposed sides 1104, 1106 and a third side 1108 configured to mate with first and second curved ends 206, 208 and first or second flat side 210, 212 of universal interface 204 of rack 200 or 300 (see FIGS. 2A-3B). End effector also includes opposed arms 1110a, 1110b that each include a flat top surface 1112a, 1112b configured to come into contact with bottom surfaces 228 or 328 of bottom plates 222 or 322 of rack 200 or 300. In other examples, a VTM robotic arm