rated from isolation zone 120 by a third divider and positioned opposite second precursor zone 116. In the embodiment shown, the third divider is a middle section of upper divider 134, which includes a series of third passageways 192 therethrough, spaced apart along third precursor zone 190. Similarly, a fourth precursor zone 194 for receiving a fourth precursor gas (Precursor 4) is positioned opposite second precursor zone 116 and separated from isolation zone 120 by an end section of upper divider 134, through which a series of spaced-apart fourth passageways 196 are provided. Precursor 4 is preferably different from Precursor 1, Precursor 2, and Precursor 3, but may alternatively be the same as Precursor 1 to achieve deposition of alternating layers of thin film materials. Third precursor zone 190 is isolated from first and fourth precursor zones 114, 194 by a pair of partition walls 198 at opposite ends of third precursor zone 190, each extending between upper divider 134 and an outer reaction chamber wall 132 of vessel 30.

[0036] In the embodiment of FIG. 2, more than two precursor zones are utilized to fabricate multiple layers of distinct materials -for example a first ten serpentine paths may traverse between first precursor zone 114 and second precursor zone 116, respectively, and the next ten serpentine paths may traverse between third precursor zone 190 and second precursor zone 116, finally, etc., resulting in multi-layer film stacks.

[0037] In one example, the system 110 illustrated in FIG. 2 may utilize TMA as Precursor 1, water as Precursor 2, $TiCl_4$ as Precursor 3, and TMA as Precursor 4 to coat 3 cycles of Al_2O_3 (approximately 0.3 nm (3Å), followed by 4 cycles of titania (TiO_2) (approximately 0,2 nm (2Å)), followed by another 3 cycles of Al_2O_3.

[0038] In another example, a thin film of aluminum-doped zinc oxide (ZnO) may be formed utilizing a system similar to the one shown in FIG. 2. Aluminum-doped ZnO is an optically transmissive conductive oxide film that may be useful as a substitute for more expensive indium-tin-oxide (ITO) electrodes commonly used in electronics and solar cells. In this example, diethylzinc (DEZn) or dimethylzinc (DMZn) are used as Precursor 1 and Precursor 4, and each of the first and fourth precursor zones 114, 194 includes between 50 and 100 turning guides (i.e., the substrate transits between 50 and 100 times in each of the first and fourth precursor zones). An oxidant, such as water, or more preferably ozone, is used as Precursor 2, and TMA is used as Precursor 3. The third precursor zone 190 may include only a very small number of turning guides (and transits) - for example two - to deposit only a doping amount of Aluminum oxide within the bulk ZnO. The substrate may then be transported through the system multiple times, in multiple passes, to achieve the desired mechanical, electrical, and optical properties.

[0039] In an alternative embodiment (not illustrated), third precursor zone 190 may be positioned between first and second precursor zones 114, 116 so that isolation zone 120 straddles third precursor zone 190 and substrate 112 traverses across third precursor zone 190 as it is transported between first and second precursor zones 114, 116. Other variations on the configuration of system 110 are also possible, the variety of configurations preferably having their various precursor zones isolated from each other by one or more isolation zones, to prevent precursor gases from reacting in any of the zones, except at the surface of substrate 112.

[0040] A system 200 shown in FIG. 3 *is not an embodiment according to the claimed invention. The system 200* may be configured without rollers, yet achieve ALD-type deposition on a long thin substrate 212, such as a web, by passing the substrate 212 along a linear transport path between alternating zones 202, 204, 206, etc., of precursor 1, inert gas, precursor 2, inert gas, precursor 1, inert gas, etc. In FIG. 3, exhaust or pumping lines from precursor zones 202, 206, etc. are omitted for simplicity. While system 200 would likely be much longer than those of FIGS. 1 and 2 for a given layer count, the system 200 of FIG. 3 could be made very thin, for example if configured as a straight-line system such as ones used for architectural glass coating systems. Accordingly, system 200 could be used to coat both flexible substrates and rigid substrates. It could also reduce issues arising, in the systems 10 and 110 of FIGS. 1 and 2, from contact between substrate 12 and the turn guides 64, 66 of substrate transport mechanism 60. In one embodiment, precursor 1 is TMA and precursor 2 is water vapor, and one pass of the substrate 212 through the system completes three ALD cycles to deposit approximately 0,3nm (three angstroms (3 Å)) of aluminium oxide (Al_2O_3). One variation on the configuration of FIG. 3 would be to have a chamber with as few zones as four, e.g., precursor 1, inert gas isolation, precursor 2, and inert gas isolation, to provide one full ALD cycle. A closed-loop substrate of flexible material (not shown) could be circulated through such a system, and the number of trips or circulations of the loop substrate through the chamber would determined the resulting coating thickness.

[0041] Some systems and methods of the kind described herein may not necessarily require highly specific geometry or mechanical configuration. For instance, in addition to the configurations illustrated in FIGS. 1-3, the substrate could be wound through a path that looks like a "zig-zag" or a sine wave, or any path, as long as the substrate winds sequentially through regions that provide at least the following: (1) exposure to one precursor; (2) an isolation zone, wherein the substrate is not exposed to one of the primary precursors; (3) exposure at least a second precursor; and (4) a second isolation zone as in step (2), which may be a common zone as that used for step (2). The substrate does not necessarily have to pass over rollers - essentially any mechanical arrangement that allows the traversal or threading of the substrate through the sequential zones would work.

[0042] FIG. 4 illustrates a system 310 according to a fourth embodiment, wherein the last two digits of 300-series reference numerals designating precursor zones 314, 316, isolation zone 320, and components of sub-