concentration of metal atoms in the stressor matrix. As the concentration of metal increases in the stressor, the energy of valence electrons in the meighboring stressed germanium rises due to bending and straining of orbitals, and the energy of the conduction band decreases. At high enough concentration, the semiconductor-metal alloy becomes a direct bandgap material (*i.e.* metallic). It may be useful, in some embodiments, to limit the metal concentration so the alloy remains an indirect bandgap material. In transistor applications, maintaining an indirect bandgap material in source/drain regions may reduce leakage.

[0016] The metal halide is provided to the processing chamber at a flow rate between about 10 sccm and about 300 sccm, such as between about 50 sccm and about 200 sccm, for example about 100 sccm. The metal halide may also be mixed with a carrier gas to achieve a desired space velocity and/or mixing performance in the processing chamber. The metal halide may be sourced from a solid source of metal halide crystals sublimed into a flowing carrier gas stream such as N_2, H_2, Ar, or He, or the metal halide may be generated by passing a halogen gas, optionally with one of the above carrier gases, over a solid metal in a contacting chamber to perform the reaction $M + 2Cl_2 \rightarrow MCl_4$, where M is Sn or Pb. The contacting chamber may be adjacent to the processing chamber, coupled thereto by a conduit which is preferably short to reduce the possibility of metal halide particles depositing in the conduit.

[0017] The metal halide and the germanium precursor are usually provided to the processing chamber through different pathways. The germanium precursor is provided through a first pathway, and the metal halide is provided through a second pathway. The two pathways are generally different and kept separate up to the point of entry into the processing chamber. In one embodiment, both streams enter through a side wall of the chamber proximate an edge of the substrate support, travel across the substrate support from one side to an opposite side thereof and into an exhaust system. The substrate support may rotate during formation of the stressed layer to improve uniformity. The first pathway generally communicates with a first entry point into the processing chamber, which may comprise one or

selectivity may be controlled by adjusting the amount of the selectivity control species relative to the reactive species in the reaction mixture.

[0023] The deposition control species is typically a halogen containing species, such as a halide, for example HCl, HF, or HBr. In one embodiment, the deposition control species is HCl. The deposition control species may be provided at a flow rate between about 10 sccm and about 1000 sccm, such as between about 100 sccmand about 500 sccm, for example about 200 sccm. Layer growth selectivity and deposition rate may be controlled by adjusting a volumetric ratio of deposition control species to germanium precursor. A higher ratio reduces deposition rate overall, but improves selectivity. The volumetric flow ratio of deposition control species to germanium precursor ranges between about 0.01 and about 0.1 for most embodiments, such as between about 0.02 and about 0.06, for example about 0.04. At the upper end of the range the deposition rate is about 50 Å/min, while at the low end of the range the deposition rate is about 500Å/min. However, at the upper end of the range, film growth on dielectric regions of the substrate is not observed, while at the lower end of the range, the deposition rate on the semiconductive regions is about 50 times the deposition rate on the dielectric regions.

[0024] The amount of compressive stress introduced by the stressor layer may be controlled at low metal concentrations by varying the concentration of metal incorporated in the stressor matrix. The metal concentration may be controlled by adjusting a ratio of metal precursor to germanium precursor in the reaction mixture. For most embodiments, the ratio of volumetric flow rates of metal precursor to germanium precursor provided to the processing chamber will be between about 1% and about 20%, such as between about 4% and about 12%, for example about 8%.

[0025] Figure 3 is a schematic diagram of an apparatus 300 according to another embodiment. The apparatus 300 is useable for practicing the methods described herein for forming stressed layers. A processing chamber 302 has a substrate support 308, which may be a rotating substrate support, disposed in an

concentration of metal atoms in the stressor matrix. As the concentration of metal increases in the stressor, the energy of valence electrons in the neighboring stressed germanium rises due to bending and straining of orbitals, and the energy of the conduction band decreases. At high enough concentration, the semiconductor-metal alloy becomes a direct bandgap material (*i.e.* metallic). It may be useful, in some embodiments, to limit the metal concentration so the alloy remains an indirect bandgap material. In transistor applications, maintaining an indirect bandgap material in source/drain regions may reduce leakage.

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