CLAIMS

1. A micro-electromechanical system (MEMS) switch comprising:

a substrate; and

a switch structure formed on the substrate, the switch structure comprising:

a conductive contact formed on the substrate;

a self-compensating anchor structure coupled to the substrate; and

a beam comprising a first end and a second end, the beam integrated with the self-compensating anchor structure at the first end and extending out orthogonally from the self-compensating anchor structure and suspended over the substrate such that the second end comprises a cantilevered portion positioned above the conductive contact;

wherein the cantilevered portion of the beam undergoes deformation during periods of strain mismatch between the substrate and the switch structure so as to have a takeoff angle relative to the substrate;

wherein the self-compensating anchor structure directs a portion of the strain mismatch orthogonally to the cantilevered portion so as to warp the anchor and compensate for the takeoff angle of the cantilevered portion; and

wherein the self-compensating anchor structure comprises a shaped anchor connection that mechanically connects the beam to the substrate, the shaped anchor connection being formed directly on a bottom surface of the switch structure, which defines a footprint, of the self-compensating anchor structure and covering only a portion of the bottom surface, such that the shaped anchor connection is contained within the footprint of the self-compensating anchor structure.

2. The MEMS switch of claim 1 wherein the shaped anchor connection is formed as one of a C-shaped anchor connection and a V-shaped anchor connection.

3. The MEMS switch of claim 1 wherein the self-compensating anchor structure comprises two or more distinct anchor connections that mechanically connect the beam to the substrate, wherein the two or more distinct anchor connections are sized, positioned, and angled on the self-compensating anchor structure so as to direct the portion of the strain mismatch orthogonally to the cantilevered portion to warp the anchor and compensate for the takeoff angle of the cantilevered portion.

4. The MEMS switch of claim 1 wherein the strain mismatch directed orthogonally to the cantilever extends less than 20% of the length of the cantilever.

5. The MEMS switch of claim 1 wherein the portion of strain mismatch directed orthogonal to the cantilevered portion develops a gradient of strain normal to the substrate, so as to pull the cantilevered portion back into an undeflected or undeformed position.

6. The MEMS switch of claim 1 wherein the portion of strain mismatch orthogonal to the cantilevered portion provided by the self-compensating anchor operates through Poisson's ratio.

7. The MEMS switch of claim 1 wherein the deformation of the cantilevered portion of the beam comprises a thermally induced deformation resulting from a coefficient of thermal expansion (CTE) between the substrate and the switch structure.

8. The MEMS switch of claim 1 wherein the beam is formed of a creep-resistant material, the creep-resistant material comprising a superalloy, including Ni-based and/or Co-based superalloys, Ni—W alloys, Ni—Mn alloys, gold containing Ni and/or Co, W, intermetallics, materials subject to solid solution and/or second phase strengthening, or a material having a crystal structure which inhibits plastic deformation.

9. The MEMS switch of claim 1 wherein the switch structure and the substrate comprise a wafer level bonded package, with an annealing implemented to form the wafer level bonded package causing the strain mismatch between the substrate and the switch structure and causing the cantilevered portion of the beam to undergo deformation resulting in the takeoff angle.

10. The MEMS switch of claim 1 wherein the beam comprises a first beam that extends out from the self-compensating anchor structure in a first direction; and

wherein the switch structure further comprises a second beam integrated with the self-compensating anchor structure, the second beam extending out from the self-compensating anchor structure in a second direction opposite the first direction in which the first beam extends.

11. The MEMS switch of claim 10 wherein the shaped anchor connection is formed as one of an I-shaped anchor connection and an X-shaped anchor connection.

12. A micro-electromechanical system (MEMS) switch comprising:

a substrate; and

a switch structure formed on the substrate, the switch structure comprising:

a conductive contact formed on the substrate;

an anchor structure coupled to the substrate; and

a beam integrated with the anchor structure and extending out orthogonally therefrom, the beam comprising a cantilevered portion suspended over the substrate and positioned above the conductive contact;

wherein the anchor structure comprises a self-compensating anchor structure that causes the cantilevered portion to remain undeflected when subjected to thermally induced takeoff angle deformation; and

wherein the anchor structure includes a shaped anchor connection that mechanically connects the anchor structure and the beam to the substrate, the shaped anchor connection formed directly on a bottom surface, which defines a footprint, of the anchor structure and covering only a portion of the bottom surface of the switch structure, such that the shaped anchor connection is contained within the footprint of the anchor structure.

13. The MEMS switch of claim 12 wherein the beam comprises a first beam that extends out from the anchor structure in a first direction, and wherein the switch structure further comprises a second beam integrated with the anchor structure, the second beam extending out from the anchor structure in a second direction opposite the first direction; and

wherein the shaped anchor connection comprises one of an I-shaped connection and a X-shaped anchor connection.

14. The MEMS switch of claim 12 wherein the shaped anchor connection comprises one of a C-shaped anchor connection and a V-shaped anchor connection.

15. The MEMS switch of claim 14 wherein the cantilevered portion undergoes deformation during thermally induced periods of strain mismatch between the substrate and the switch structure, so as to cause the takeoff angle deformation; and

wherein the self-compensating anchor structure directs a portion of the strain mismatch orthogonal to the cantilevered portion so as to warp the anchor structure and compensate for the takeoff angle deformation.

16. A method of manufacturing a micro-electromechanical system (MEMS) switch, the method comprising:

providing a substrate; and

forming a switch structure on the substrate via a wafer level bonding process, wherein forming the switch structure further comprises:

forming a conductive contact on the substrate;

forming a self-compensating anchor structure on the substrate, the self-compensating anchor structure comprising a shaped anchor connection formed directly on a bottom surface of the switch structure, which defines a footprint, of the self-compensating anchor structure and covering only a portion of the bottom surface, such that the shaped anchor connection is contained within the footprint of the self-compensating anchor structure; and

attaching a cantilevered beam to the self-compensating anchor structure to position the cantilevered beam relative to the substrate and the conductive contact, the cantilevered beam comprising a cantilevered portion at an end thereof opposite the self-compensating anchor structure;

wherein the self-compensating anchor structure is arranged orthogonally to the cantilevered portion of the cantilevered beam, with the cantilevered portion extending out so as to be spaced apart from the substrate and positioned above the conductive contact; and

performing an annealing process on the substrate and the switch structure to achieve bonding in the MEMS switch;

wherein the cantilevered portion of the beam undergoes deformation during the annealing process responsive to a strain mismatch between the substrate and the switch structure, such that the cantilevered portion has a takeoff angle relative to the substrate; and

wherein the self-compensating anchor structure directs a portion of a strain resulting from the strain mismatch orthogonal to the cantilevered portion so as to warp the anchor structure and compensate for the takeoff angle of the cantilevered portion.

17. The method of claim 16 wherein the shaped anchor connection comprises one of a C-shaped anchor connection and a V-shaped anchor connection.

18. The method of claim 16 wherein attaching the cantilevered beam to the self-compensating anchor structure comprises:

attaching a first cantilevered beam to the self-compensating anchor structure such that the first cantilevered beam extends out from the self-compensating anchor structure in a first direction; and

attaching a second cantilevered beam to the self-compensating anchor structure such that the second cantilevered beam extends out from the self-compensating anchor structure in a second direction opposite the first direction;

wherein the shaped anchor connection comprises one of an I-shaped anchor connection and an X-shaped anchor connection.

19. The method of claim 16 wherein the strain orthogonal to the cantilevered portion provided by the self-compensating anchor structure operates through Poisson's ratio.