the substrate **206** before etching the conductive layers **202**, **204** and insulating layer **208** to define the comb fingers **214**, **216**.

A third embodiment of the present invention is illustrated in FIGS. **3A–3I**, which shows a method of fabricating a multi-layer vertical comb-drive structure of the type shown in FIGS. **1B–1C**. In this method, one set of comb fingers has two layers, while the other has only one layer. FIG. **3A** shows a structure **300** containing first conductive layer **302** and second conductive layer **304**, and first and second insulating layers **306** and **308**, respectively. Also shown is optional substrate layer **310**. Structure **300** may be identical to substrate **200** of FIG. **2A**. Conductive layers **302** and **304** are preferably silicon, while insulating layers **306** and **308** are preferably a silicon oxide formed from thermal oxidation of silicon wafer layers **302** and **304**, which are then bonded together.

In FIG. **3B**, a first masking layer **312** (e.g. silicon oxide, aluminum, photoresist) is deposited and patterned on top of first conductive layer **302**. Some of the remaining portions of the masking layer cover areas that will eventually become the first comb fingers. Next, in FIG. **3C**, a second masking layer **314** (e.g. photoresist) is deposited on top of first masking layer **312** and then removed according to a second pattern, defining the location of eventual comb fingers. Layers **312** and **314** contain different types of masking material, so that one can be selectively removed without affecting the other. In FIG. **3D**, regions **316** of first masking layer **312** that are not covered by second masking layer **314** are removed. This ensures that the second mask **314** defines the comb structures. Therefore, the alignment between the first mask **312** and the second mask **314** does not affect the comb widths. Next, in FIG. **3E**, first conductive layer **302**, first insulating layer **316**, and second conductive layer **304** are etched, e.g., using deep reactive-ion etching (DRIE) to create two sets of comb fingers **322**, **324** that will respectively become second and first comb fingers. The second masking layer **314** is then removed to create the structure of FIG. **3F**, which is etched using DRIE or other anisotropic silicon etching methods to remove the first conductive layer **302** from alternating comb fingers. The resulting structure is shown in FIG. **3G**. The fingers are then undercut in FIG. **3H**, followed by optional removal of portions of the first and second insulating layers **306** and **308** and remaining first masking layer **312** to reveal an actuator **330** of FIG. **3I**. Insulating oxide layers may be removed using a timed HF etch. In the embodiment shown, second comb fingers **322** are connected to a second comb bridge in a plane parallel to the plane of the paper, either above or below the page. The second comb bridge may be connected to the substrate through a torsion hinge or flexure that allows movement of the second comb structure. One method to operate actuator **330** is to apply a voltage V to the second comb fingers **322** and a bottom layer **324**B of the first comb fingers **324**, while a top layer **324**A of first comb fingers **324** is grounded, causing an electric force that moves the second comb fingers **322**.

Note that the method illustrated in FIGS. **3A–3I** can also be used to create an actuator in which the first comb fingers have a single layer and the second fingers have two layers, in which case application of a voltage causes the second fingers to rotate downward. This method requires slightly different patterning of the two types of masking layers.

Actuators of the present invention may be used for any suitable application. Two-dimensional actuators may be fabricated using similar processes. Depending on the application needed, additional steps may be added into the fabrication process to create an integrated device. Metals may be evaporated, sputtered, or electroplated onto the substrate using methods known in the art.

In both embodiments of the fabrication method shown, all of the fingers are formed in a single process in a single multi-layer wafer structure, thus providing for very high precision in alignment of the comb fingers.

It will be clear to one skilled in the art that the above embodiment may be altered in many ways without departing from the scope of the invention. Accordingly, the scope of the invention should be determined by the following claims and their legal equivalents.

What is claimed is:

1. A multi-layer vertical comb-drive actuator comprising:

a) a first comb structure having a plurality of first comb fingers; and

b) a second comb structure having a plurality of second comb fingers, wherein the second comb structure is positioned such that the second comb fingers are interdigitated and self aligned with the first comb fingers;

wherein the first comb fingers include at least one first conductive layer and at least one second conductive layer, wherein the first and second conductive layers are electrically isolated from each other, and

wherein the second comb fingers include a first and a second conductive layer, wherein the first and second conductive layers of the second comb fingers are electrically isolated from each other.

2. The multi-layer vertical comb-drive actuator of claim **1** wherein the first and second conductive layers of the first comb fingers are electrically isolated by an insulating layer.

3. The multi-layer vertical comb-drive actuator of claim **1** wherein the first and second conductive layers are isolated by an air gap.

4. The multi-layer vertical comb-drive actuator of claim **1**, wherein one or more of the second comb fingers of the second comb structure has at least one first conductive layer that is substantially aligned with the first conductive layer of the first comb fingers of the first comb structure.

5. The multi-layer vertical comb-drive actuator of claim **4**, wherein an application of a voltage between the second conductive layers of the first comb fingers and the first conductive layers of second comb fingers causes relative movement between the first and second comb structures.

6. The multi-layer vertical comb-drive actuator of claim **1**, wherein the first and second conductive layers of the second comb fingers are electrically isolated by an insulating layer.

7. The multi-layer vertical comb-drive actuator of claim **1**, wherein the first and second conductive layers of the second comb fingers are electrically isolated by an air gap.

8. The multi-layer vertical comb-drive actuator of claim **1**, wherein an application of a voltage between the first conductive layer of the first comb fingers and the second conductive layer of the second comb fingers causes the second comb structure to move relative to the first comb structure.

9. The multi-layer vertical comb-drive actuator of claim **1**, wherein an application of a voltage between the second conductive layer of the first comb fingers and the first conductive layer of the second comb fingers causes the second comb structure to move relative to the first comb structure.

10. The multi-layer vertical comb-drive actuator of claim **1**, wherein the first comb structure and the second comb structure are fabricated from a common substrate containing the first and second conducting layers.

11. The multi-layer vertical comb-drive actuator of claim **1** further comprising a means for measuring a capacitance between the first comb fingers and the second comb fingers.