X- and Y- axes of the chip. It is noted that a two dimensional sensor device can also be made by further providing an additional one dimensional sensor corresponding to that shown in FIG. **1**, but rotated by 90°, so that this sensor, in combination with the sensor of FIG. **1**, will provide the requisite two dimensional sensing.

In a specific example of the sensor fabrication method or process of the invention, chips were fabricated in a double-poly 2 m CMOS n-well operation through the MOSIS service and were subsequently etched in a laboratory. Details of the initial processing are described in the Tea et al article referenced herein above. In general, Refering to FIG. **3**A and **3**B resistive heater element **14**, and thermocouple elements **16**, **18** are patterned as an integrated circuit (IC) on the chip **10** as a pre-cursor to the etching step. As shown, and is conventional, the thermocouple elements **16** and **18** are constructed of two thermocouple members **16***a* and **16***b* and **18***a* and **18***b*, respectively, which are made of different thermocouple materials and which form respective hot junctions H and cold junctions C. The heater element **14** and thermocouple elements **16**, **18** are encapsulated in a glass passivation layer **24** formed on the IC substrate **26** of IC chip **10**. Standard IC techniques are used and this can be done at a CMOS foundry. The design of the integrated circuit on the chip **10** includes the provision of openings or windows **28** in the glass passivation layer **24** which is a part of the IC chip. These openings or windows **28** serve as etch sites for the etching operation that creates etch cavity **12** and, in essence, the design or pattern created on the chip **10** provides the necessary masking for the etching operation. Thereafter, in a post-processing, micromachining step, shown in FIG. **3**B the portions of the chip around and under the heater element **14** and thermocouple elements **16**, **18** are micromachined or etched away, in a maskless etching step, so that these elements are suspended on the chip **10** above the etch cavity **12**. The etching step is maskless in the sense that no further masking is needed to perform this step other than that provided by the IC patterning, although further masking can, of course, be used if desired or necessary. In the embodiment illustrated in FIG. **3**B, and is also shown schematically in FIG. **4**, the hot junctions H of thermocouples **16** and **18** are suspended over cavity **12** while the substrate **26** is etched up to the cold junctions C so that the latter remain in the substrate **26**.

As described above in connection with the Dao et al patent, a convective accelerometer conventionally includes a sealed enclosure containing a heating element and two temperature sensing elements. In FIG. **1**, a sealed enclosure or package **30** is shown which is provided to enclose the IC chip **10** forming the convective accelerometer of the invention, as a final step in the preparation of the overall device.

As shown in FIG. **1**, the heater **14** is mounted on chip **10** with glass-cut areas **12***a* and **12***b* on both sides thereof. It is noted that because there is no overlap of the open areas **12***a* and **12***b* on the opposite sides of heater **14**, an anisotropic etch would not result in suspended structures but would instead form two separate etch pits or cavities. For this reason, a gaseous isotropic etchant, preferably xenon-difluoride, is used. After a predetermined time period, typically about 6 minutes (the period it takes to produce 12 pulses of 30 second duration), the silicon substrate structure is entirely suspended, up to the cold thermocouple junctions (not shown) which must remain on the silicon substrate. The resulting devices are suitably thermally isolated from the substrate so as to achieve temperatures as high as 1000K for small input powers (i.e., powers less than 100 mW).

In making the two dimensional device of FIG. **2**, in one example, the device was also suspended by isotropic etching to simplify post-processing. However, due to the polygonal glass cut configuration employed, anisotropic etching could also be used. Such anisotropic etching can be carried out using an anisotropic etchant such as ethylene diamine-pyrocatechol-water (EDP). Otherwise, the basic process is the same.

The sensor device of the invention has been used to perform measurements in various applications. In one test thereof, the sensor device was mounted on an optical goniometer and tilted from θ−90° to 90° of angle where θ is an angle between a normal to the chip surface and the gravity vector. For this test, constant power was provided to the heater (**14**), instead of constant voltage or current, in order to control the instability of the suspended polysilicon resistor forming the heater. Tilt sensor results were a very good fit with the expected sinusoidal trend. Other tests involved the use of a standard vibration exciter or shaker, with an acceleration range from 0 to 8 g and vibration frequencies of 10 Hz to 200 Hz. Another test involved varying the power to the microheater (**14**) and showed the expected dependence of sensor sensitivity to the change in applied power to the heater.

Although the invention has been described above in relation to preferred embodiments thereof, it will be understood by those skilled in the art that variations and modifications can be effected in these preferred embodiments without departing from the scope and spirit of the invention.

What is claimed is:

1. A method of manufacture of a convective accelerometer and tilt sensor device, said method comprising:

providing an integrated circuit chip comprising a substrate having an integrated circuit pattern thereon including a heater element located centrally of said substrate and at least first and second thermocouple elements located on said substrate on opposite sides of said heater element; and

etching away portions of the substrate surrounding and beneath the heater and thermocouple elements to form a cavity therebeneath to suspend said element on said substrate so as to thermally isolate said elements from the substrate and so that an air gaD contiguous with said cavity is formed between said heater element and each of said thermocouple elements.

2. A method of manufacture according to claim **1** wherein said heater element includes a plurality of heaters arranged in a symmetrical pattem and wherein a thermocouple element is associated with each of said heaters.

3. A method of manufacture according to claim **2** wherein said plurality of heaters comprises four heaters arranged in a square configuration and a thermocouple element is arranged opposite to each of said four heaters outwardly thereof.

4. A method of manufacture according to claim **1** wherein said heater element comprises a single heater extending completely across said substrate and said etching of the substrate comprises using a gaseous isotropic etchant to perform said etching.

5. A method of manufacture according to claim **4** wherein the gaseous isotropic etchant comprises xenon-difluoride.

6. A method of manufacture according to claim **1** wherein said etching of said substrate comprises using an anisotropic etchant to perform said etching.

7. A method of manufacture according to claim **1** wherein the thermocouple elements include hot and cold thermocouple junctions and the substrate is etched up to the cold