MICRO-HOTPLATE DEVICES AND METHODS FOR THEIR FABRICATION

TECHNICAL FIELD

The present invention relates to silicon micromachining techniques and devices made thereby. In particular, the present invention relates to micro-hotplate devices and methods of fabricating the same.

BACKGROUND ART

The field of silicon micromachining has been researched for over 20 years. Although most of the recent media attention has focused on micro-motors and gears, other applications of silicon micromachining currently exist, including applications in sensor technologies.

Traditionally, silicon micromachined devices are manufactured in custom fabrication environments since the process steps for their fabrication significantly deviate from those for integrated circuits (IC's). In contrast to custom fabrication environments which are highly specific and extremely costly, IC's processed in silicon foundries offer the customer low cost and reliable custom parts. Many of these commercial foundries, also called Application Specific Integrated Circuit (ASIC) foundries, currently exist in the United States. These foundries are very reluctant to deviate from their standard processes to accommodate such things as silicon micromachined devices since they generally invested great amounts of time and money to optimize their processes for circuits. To date, no commercial ASIC foundry has made such a deviation.

The trend for silicon micromachined devices is moving in the direction of integration of mechanical elements with circuits. One example of this class of devices is "smart" sensors. Since the process of manufacturing sensors is significantly different from the IC process, the integration of circuits with sensors is a challenging problem. Recently, a technique was developed by Parameswaran (M. Parameswaran et al, "A New Approach for the Fabrication of Micromachined Structures", *Sensors and Actuators*, Vol. 19 (1989), pages 289–307) which allows for the fabrication of a class of micromechanical devices using chips that are commercially fabricated.

The inventors of the present invention have previously collaborated with Parameswaran (currently at Simon Fraser University in Vancouver) in the development of suspended heating elements to be used as micro-light sources for application as pixels in thermal displays (M. Parameswaran et al, "Micromachined Thermal Radiation Emitter from a Commercial CMOS Process", *IEEE Electron Device Letters*, Vol. 12, No. 2 (1991), pages 57–60). This collaborated work was based on CMOS compatible surface micromachining techniques.

While working on thermal displays, the present inventors envisioned that a similar type structure could be used to make a micro-hotplate device that had a polysilicon heating element (as in thermal display devices) and an aluminum plate to sense temperature and to distribute heat. Such a device could be easily integrated with circuitry for drive and control of the sensor and for communication with computers.

Similar ideas have been reported by Wang et al ("A Microfabricated Array of Multiple Thin Film Metal Oxide Sensors for Multicomponent Gas and Vapor Quantification", *Proceedings from the IEEE Solid State Sensors and Actuators Workshop*, Hilton Head, S.C. (1992), page 23), and Najafi et al ("An Integrated Multi-Element Ultra-Thin-Film Gas Analyzer", *Proceedings from the IEEE Solid State Sensors and Actuators Workshop*, Hilton Head, S.C. (1992), page 19). However, the methodologies for design and fabrication of these reported devices involve custom fabrication processes which limit the commercialization thereof. In addition, the components for the heating element and membrane are different from that of the present invention.

BRIEF SUMMARY OF THE INVENTION

It is accordingly one object of the present invention to provide a micro-hotplate structure which can be fabricated by conventional techniques which allow the manufacture of arrays of the micro-hotplate structures on a single substrate. It is a further object of the present invention to provide a micro-hotplate device which includes a conductive heat distribution plate which evenly distributes heat and means to sense the temperature of the device. A still further object of the present invention is to provide a micro-hotplate which includes means to measure electrical properties of materials which come into contact therewith. A still further object of the present invention is to provide for a method of fabricating the micro-hotplate devices which is based upon conventional techniques.

According to these and further objects of the present invention which will become apparent as the description thereof proceeds, the micro-hotplates of the present invention include a support substrate having a suspended microbridge structure formed thereon. A heating element is formed on the microbridge structure. The microbridge structure ensures that the heating element is thermally isolated from the support substrate. A conductive heat distribution plate is formed above the heating element. The conductive heat distribution plate is provided for evenly distributing heat from the heating element.

The present invention also provides an array of micro-hotplate devices.

The present invention further provides a method of making a micro-hotplate device. This method involves providing a support substrate having a first layer of an insulating material. Portions of the first layer of insulating material are identified as opening portions and a bridge portion. To fabricate the microbridge structure, the first layer of insulating material is removed from the opening portions and a portion of the substrate beneath the bridge portion is etched out through the opening portions so as to suspend and thermally isolate the bridge portion from the support substrate. Prior to etching, a heating element is formed on the bridge portion, a second layer of insulating material is formed on the heating element, a conductive heat distribution plate is formed on the second layer of insulating material, and a third layer of insulating material is formed on the conductive heat distribution plate.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will hereafter be described with referenceto the annexed drawings which are given by way of non-limiting examples only in which:

FIG. 1A is a schematic drawing showing the open areas and the heating element according to one embodiment of the present invention.

FIG. 1B is a schematic drawing showing an alternative/ embodiment of the heating element.