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(54) **TEST KEY HAVING A CHAIN CIRCUIT AND A KELVIN STRUCTURE**

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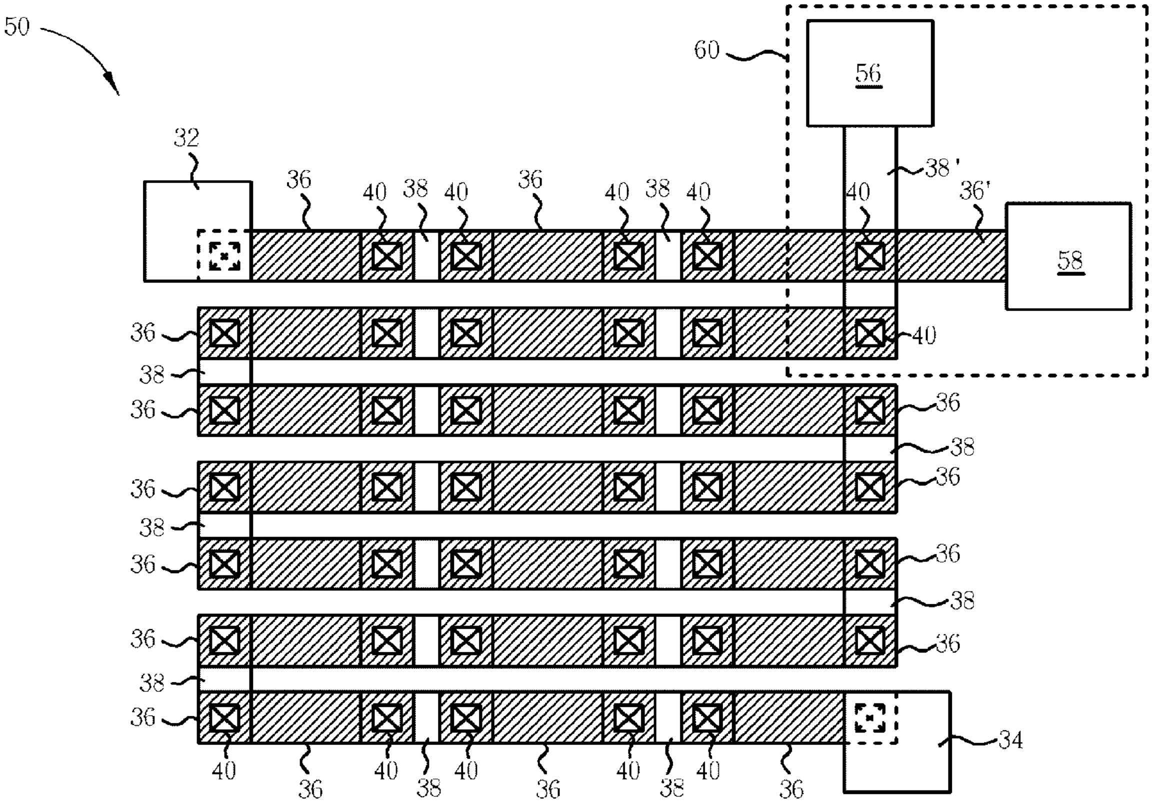
(57) **ABSTRACT**

A test key formed on a semiconductor substrate has a plurality of electronic components, a plurality of conductors, a plurality of vias for connecting the electronic components and the conductors, a first pad, a second pad, a third pad, and a fourth pad. The first pad, the electronic components, the vias, the conductors, and the second pad connects in series to form a chain circuit, and the first pad and the second pad are positioned at two ends of the chain circuit. A Kelvin structure is composed of the third pad, the fourth pad, one of the conductors, one of the vias, and one of the electronic components.



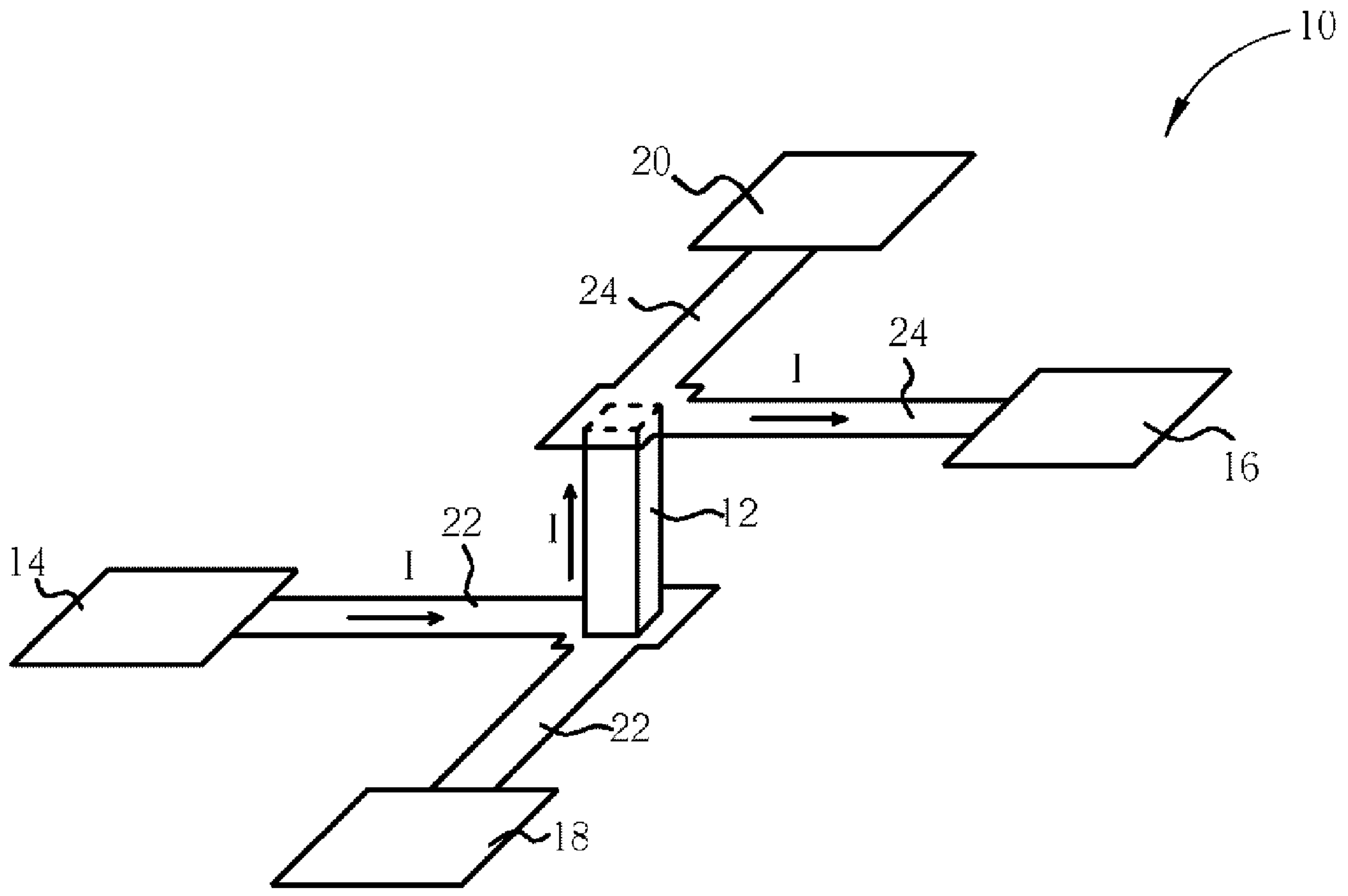


Fig. 1 Prior Art

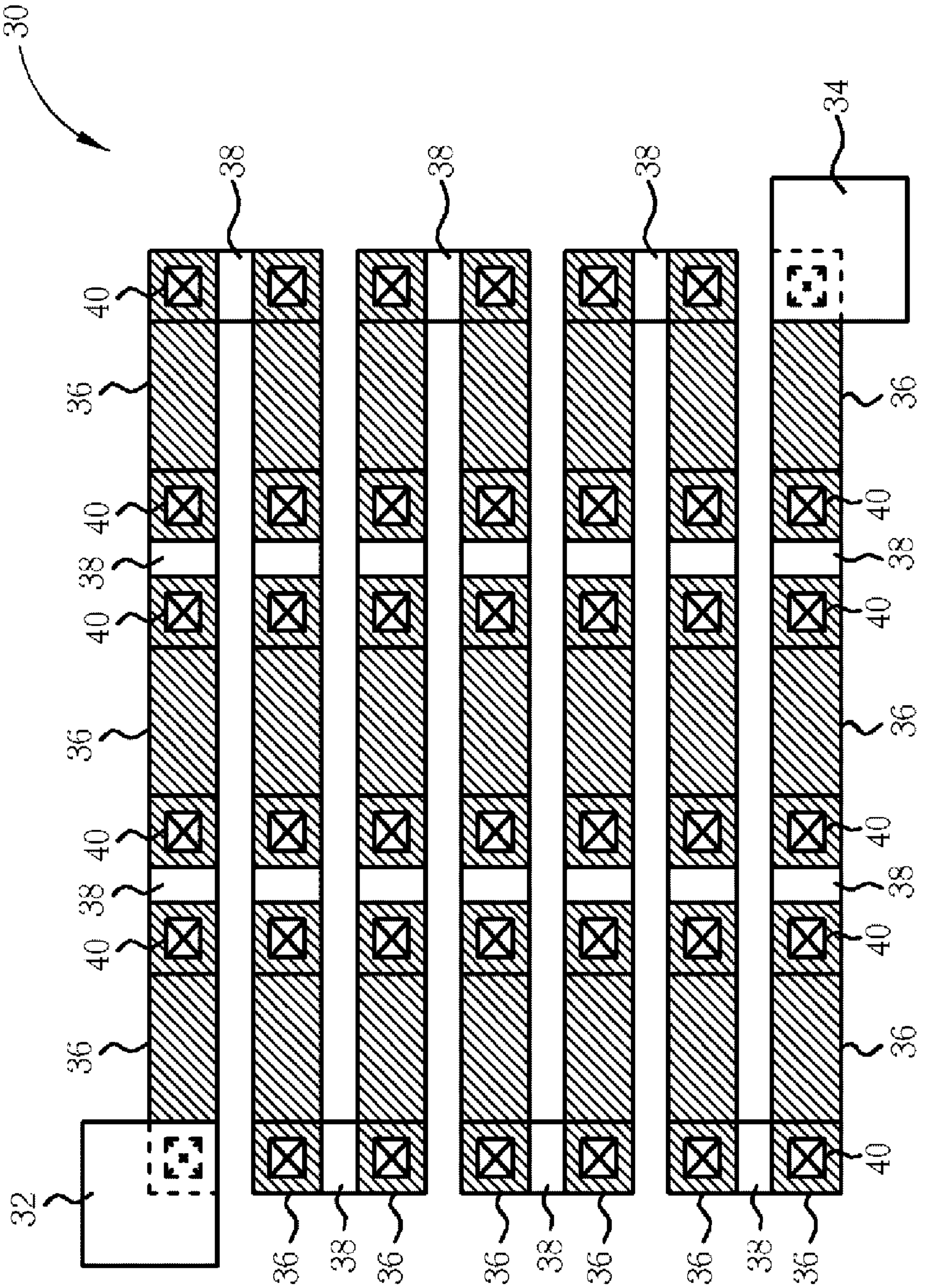


Fig. 2 Prior Art

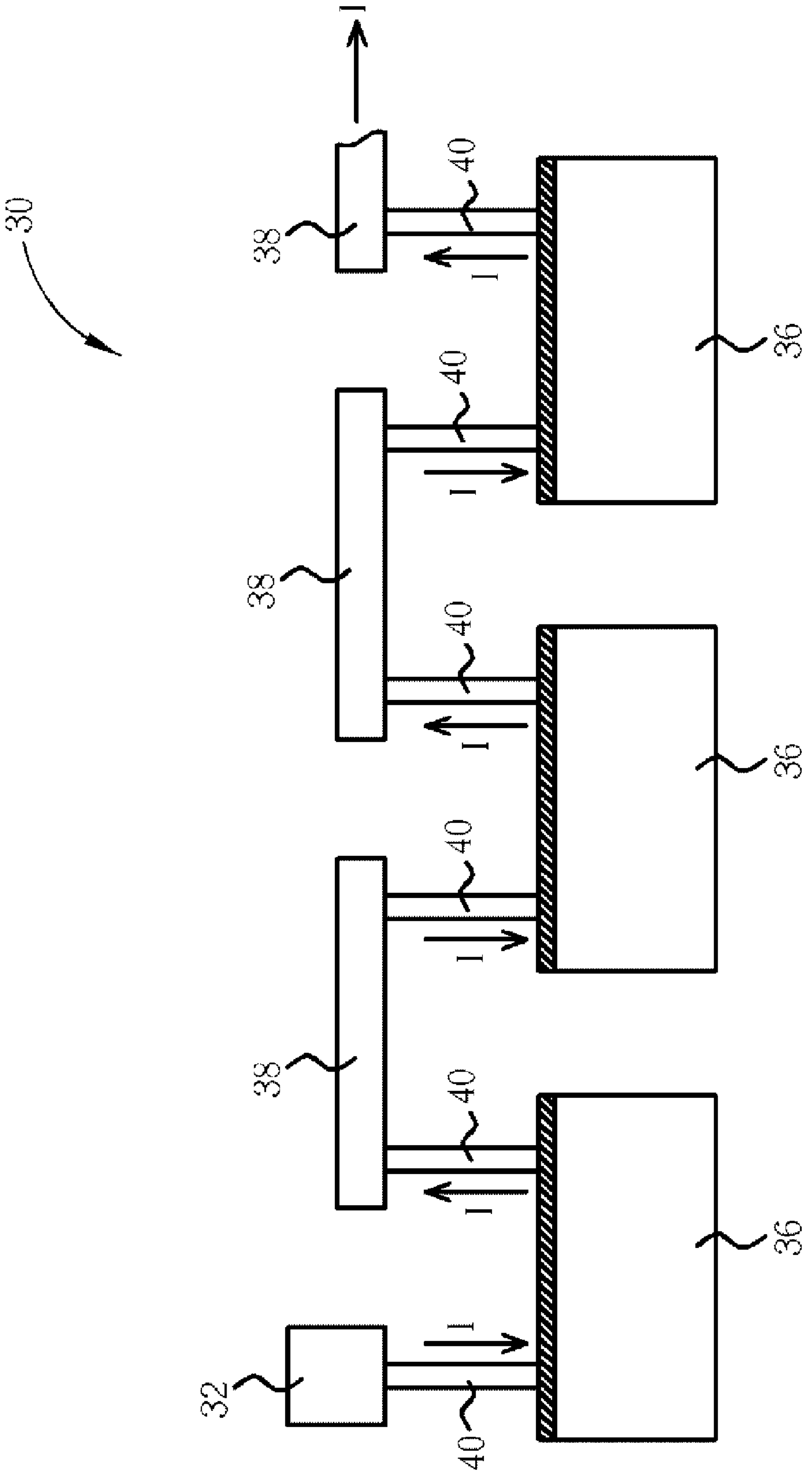
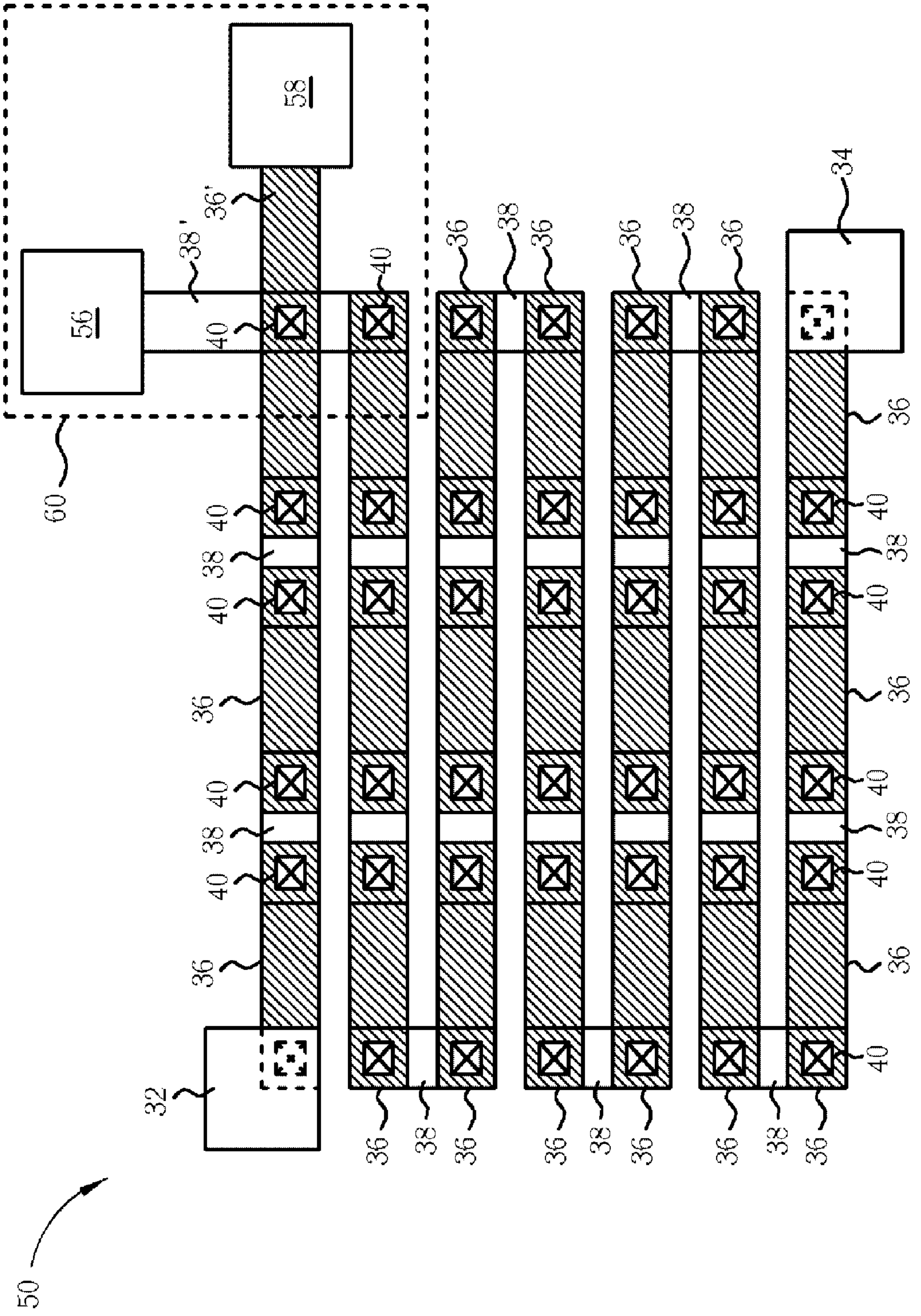


Fig. 3 Prior Art


58
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36'
38'
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Fig. 4

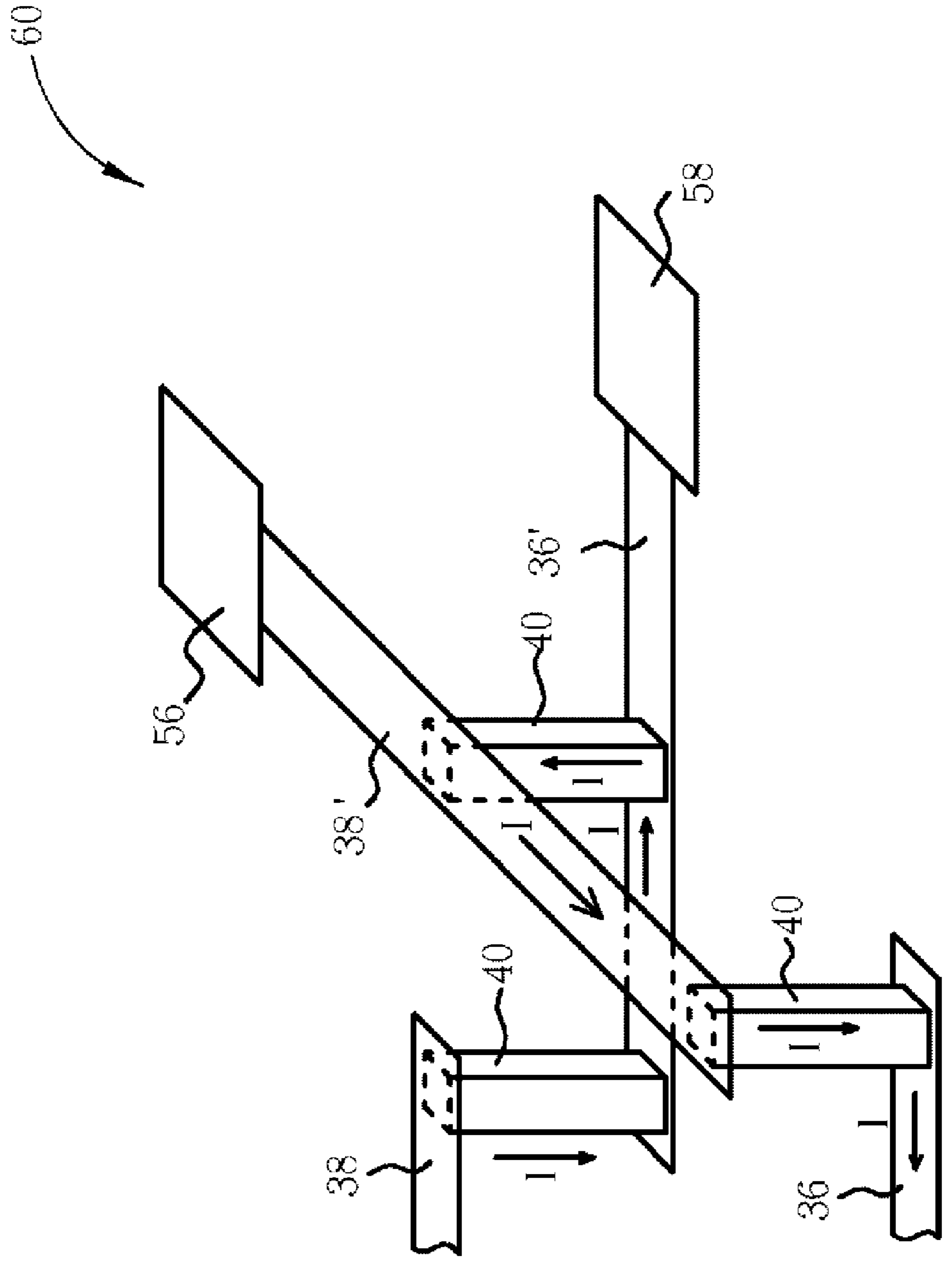

Fig. 5

TEST KEY HAVING A CHAIN CIRCUIT AND A KELVIN STRUCTURE

BACKGROUND OF INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a test key in a semiconductor substrate, and more particularly, to a test key having a chain circuit and a Kelvin structure.

[0003] 2. Description of the Prior Art

[0004] In semiconductor fabrication, a semiconductor device or an integrated circuit (IC) is continuously tested in every step so as to maintain device quality. Normally a testing circuit is simultaneously fabricated with an actual device so that the quality of the actual device is judged by the performance of the testing circuit. The quality of the actual device therefore is well controlled. Moreover, because of the advanced semiconductor technology, the number of transistors in a single chip is grown so that the amount of the vias for interconnecting the transistors is increased rapidly. In order to handle the yield of the semiconductor products, how to accurately measure the resistances of the vias has been an important issue.

[0005] Please refer to **FIG. 1**, which is a schematic diagram of a test key **10** according to the prior art. The test key **10** has a Kelvin structure that is used to measure the resistance of a via **12**. The test key is formed on a semiconductor substrate and comprises a first pad **14**, a second pad **16**, a third pad **18**, a fourth pad **20**, and two wires **22**, **24**. The via **12** is connected with the four pad **14-20** via the two wires. When measuring the resistance of the via **12**, four probes of a probe card are used to contact the four pads **14-20** respectively. The probe card provides a test current I to the test key **10** via the first pad **14** and the second pad **16**. The test current I flows through the via **12**. Meanwhile, the probe card measures the voltage gap between the two ends of the via **12** by contacting the third pad **18** and the fourth pad **20**. Then, the resistance of the via **12** is calculated according to the test current I and the measured voltage gap between the two ends of the via **12**. However, because of the single via **12**, the test key **10** has etching loading effect.

[0006] Please refer to **FIGS. 2-3**. **FIG. 2** is a layout diagram of another test key **30** according to the prior art, and **FIG. 3** is sectional diagram of the test key **30**. The test key **30** is formed on a semiconductor substrate and has a chain structure. The test key **30** comprises a first pad **32**, a second pad **34**, a plurality of electronic components **36**, a plurality of conductors **38**, and a plurality of vias **40**. The conductors **38** are metal wires, and the electronic components **36** are diffusion areas or metal wires under the conductors **38**. The vias **40** connect the first pad **32**, the second pad **34**, the electronic components **36**, and the conductors **38** together. Therefore, the first pad **32**, the electronic components **36**, the conductors **38**, the vias **40**, and the second pad **34** are connected in series as a chain circuit. And, the first pad **32** and the second pad **34** are respectively positioned at the two ends of the chain circuit. When testing the test key **30**, two probes of a probe card contact the first pad **32** and the second pad **34** to supply a test voltage to the first pad **32**. Normally, as shown in **FIG. 3**, a test current I flows through the electronic components **36**, the vias **40**, and the conductors **38**. The probe card measures the test current I so as to calculate the equivalent resistance between the first pad **32** and the second pad **34**. And then, the probe card estimates the resistance of each via **40** according to the equivalent resistance between the first pad **32** and the second pad **34**. Even the test key **30** has no etching loading effect, but the estimated resistance of each via **40** is not very accurate. The application of the estimated resistance of each via **40** is not very practical.

SUMMARY OF INVENTION

[0007] It is therefore a primary object of the present invention to provide a test key that has a chain circuit and a Kelvin structure to solve the above-mentioned problems.

[0008] A test key is formed on a semiconductor substrate and has a plurality of electronic components, a plurality of conductors, a plurality of vias for connecting the electronic components and the conductors, a first pad, a second pad, a third pad, and a fourth pad. The first pad, the electronic components, the vias, the conductors, and the second pad connects in series to form a chain circuit, and the first pad and the second pad are positioned at two ends of the chain circuit. A Kelvin structure is composed of the third pad, the fourth pad, one of the conductors, one of the vias, and one of the electronic components.

[0009] Because the test key has the Kelvin structure, the resistance of a single via can be measured accurately. In addition, the test key has the plurality of vias, so the test key has no etching loading effect.

[0010] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0011] **FIG. 1** is a schematic diagram of a test key according to the prior art.

[0012] **FIG. 2** is a layout diagram of another test key according to the prior art.

[0013] **FIG. 3** is sectional diagram of the test key shown in **FIG. 2**.

[0014] **FIG. 4** is a layout diagram of the test key according to the present invention.

[0015] **FIG. 5** is schematic diagram of a Kelvin structure of the test key shown in **FIG. 4**.

DETAILED DESCRIPTION

[0016] Please refer to **FIGS. 4-5**. **FIG. 4** is the layout diagram of a test key **50** according to the present invention, and **FIG. 5** is the schematic diagram of a Kelvin structure **60** of the test key **50**. The key **50** has a similar circuit structure to the test key **30**. The difference between the two test keys **30** and **50** is that a segment of the chain circuit of the test key **30** is replaced by the Kelvin structure **60** of the test key **50**.

[0017] Similar to the test key **30**, the test key **50** is also formed on a semiconductor substrate. The test key **50** comprises a first pad **32**, a second pad **34**, a third pad **56**, a fourth pad **58**, a plurality of electronic components **36-36'**, a plurality of conductor **38-38'**, and a plurality of vias **40**. In the embodiment, the conductors **38** and **38'** are metal wires, and the electronic components **36** and **36'** are metal wires in a metal layer under the conductors **38** and **38'**. It is noted that the present invention should not be limited in such case. For example, the electronic components **36** and **36'** can be conductive diffusion areas. The vias **40** are used to connect the first pad **32**, the second pad **34**, the electronic components **36-36'**, and the conductors **38-38'** in series to from a chain circuit. And the first pad **32** and the second **34** are respectively positioned at the two ends of the chain circuit.

[0018] As previously mentioned, a segment of the test key **30** is replaced by the Kelvin structure **60** of the test key **50**. As shown in **FIG. 5**, the Kelvin structure **60** is composed of the third pad **56**, the conductor **38'**, the electronic component **36'**, the fourth pad **58**, and a specific via **40** that is connected with the electronic component **36'** and the conductor **38'**. The electronic component **36'** is coupled to the pad **56**, and the conductor **38'** is coupled to the fourth pad **58**.

[0019] When testing the test key **50**, four probes of a probe card are used to contact the four pads **32**, **34**, **56**, and **58**. The probe card tries to output a test current I to the test key **50** via the first pad **32** and the second pad **34** to detect whether all components of the test key **50** are connected properly. If the test current I is successfully outputted to the test key **50**, it is indicated that all components of the test key **50** are connected properly. In such situation, the test current I flows from the first pad **32** through the electronic components **36-36'**, the conductors **38-38'**, and the vias **40** to the second pad **34**. However, if the probe card cannot output the test current I to the test key **50**, it is indicated that all components of the test key **50** may be not connected properly. In other words, the path from the first pad **32** to the second pad **34** may be opened. In addition, the probe card measures the voltage gap between the two ends of the specific via **40**, which is connected with the electronic component **36'** and the conductor **38'**. Then, the resistance of the specific via **40** can be accurately measured according to the voltage gap measured by the probe card. Therefore, because of the circuit structure of the test key **50**, not only the resistance of a single via **40** can be measured accurately, but also any connection defect among the components of the test key **50** can be detected.

[0020] In comparison with the prior art, the test key according to the present invention has a Kelvin structure for accurately measuring the resistance of a single via. In addition, the etching loading effect can be avoided, and any connection defect among the components of the test key **50** can be detected. Therefore, in the same size of layout area, the test key according to the present invention is more functional.

[0021] Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

1. A test key formed on a semiconductor substrate, the test key comprising:

a plurality of electronic components formed in the semiconductor substrate;

a plurality of conductors formed in a conductive layer;

a plurality of vias for connecting the electronic components and the conductors;

a first pad;

a second pad, wherein the first pad, the electronic components, the vias, the conductors, and the second pad connect in series to form a chain circuit, and the first pad and the second pad are positioned at two ends of the chain circuit;

a third pad electrically connected to a first end of a test via; and

a fourth pad electrically connected to a second end of the test via; wherein the third and fourth pads of the test key measure a voltage gap between the first and second ends of the test via.

2. The test key of the claim 1 wherein the electronic components are diffusion areas formed in the semiconductor substrate.

3. The test key of the claim 1 wherein the conductors are made of metal material.

4. A test key formed on a semiconductor substrate, the test key comprising:

a plurality of electronic components formed in the semiconductor substrate;

a plurality of conductors formed in a conductive layer;

a plurality of vias for connecting the electronic components and the conductors;

a first pad;

a second pad, wherein the first pad, the electronic components, the vias, the conductors, and the second pad connect in series to form a chain circuit, and the first pad and the second pad are positioned at two ends of the chain circuit;

a third pad electrically connected to a first end of a test via through a test conductor; and

a fourth pad electrically connected to a second end of the test via through a test electronic component;

wherein the third and fourth pads of the test key measure a voltage gap between the first and second ends of the test via.

5-6. (canceled)

7. The test key of the claim 4 wherein the electronic components are diffusion areas formed in the semiconductor substrate.

8. The test key of the claim 4 wherein the conductors are made of metal material.

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