

Micro-four-point probes fabricated on microcantilever system.

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Summary

In this research, we propose a new type of micro-four-point probe (μ 4PP) to measure electrical properties of sample surfaces with different shapes. The device consists of a main cantilever and four sub-cantilevers that are arranged at the end of the main cantilever. A thermal actuator is integrated on each sub-cantilever. Hence, the device can be used as a micro-gripper to move small subjects. Resistance measurement on a metal particle is successfully performed using the μ 4PP. The measured sheet resistance differs by less than 10% from the data provided by the company.

Motivation

Electrical resistivity of thin films or semiconductor substrates is commonly measured using the four-point probe method. This method practically eliminates measurement error due to contact resistances. There is some interest in the miniaturization of the device to obtain much higher sensitivity and less damage to the sample surfaces. Several attempts based on silicon micromachining have been made to improve 4PP characteristics, including a desire to decrease its probe-to-probe spacing for further applications. However, there is the fundamental limitation to reduce the spacing of probe tips because the tips are lined up. We suggest a new 4PP design as shown in Figure 1, a new fabrication method for in-plane tips – the main cantilever supports four sub-cantilevers with the in-plane tip where the ends of the four sub-cantilever tips are facing each other. Initial probe-to-probe spacing of the devices is about 50 μ m and can be decreased to 500 nm by using e-beam. A spring constant of the sub-cantilever is less than 0.5 N/m, which is suitable for fragile materials such as biomaterials.

Results

Figure 2 shows the process flow of key steps in the fabrication of the μ 4PP. A new fabrication method is only developed to make the in-plane tip. First, the shape of the in-plane tip is defined in SiO₂ by photolithography. Then, the SiO₂ is wet-etched until the neck width of the base-shaped mask is 0. After removing the photoresist in acetone, silicon is dry-etched using an SF₆-based RIE. Finally, the SiO₂ is removed in a solution of buffered hydrofluoric acid, which defines the in-plane tip at the free end of the sub-cantilever. This novel process produces a very sharp tip end and eliminates the use of special equipment such as an e-beam lithography system. Figure 3 shows optical and SEM images of the fabricated in-plane tips. For other parts, we use conventional micromachining techniques. Figure 4 shows an SEM image of fabricated μ 4PP and the sub-cantilever is initially curled by a thin metal layer. Figure 5 shows an experimental setup to measure electrical property of a metal particle. The measured resistivity is almost the same as that of the value provided by the company.

References

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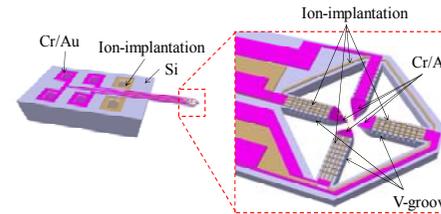


Figure 1. A schematic diagram of a new type micro four-point probe.

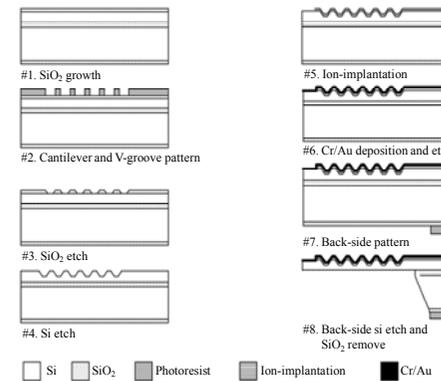


Figure 2. Process flow of key steps in the fabrication of the μ 4PP

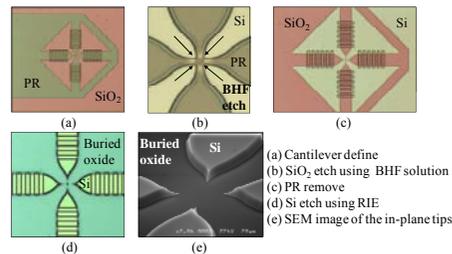


Figure 3. Process flow for the in-plane tip fabrication

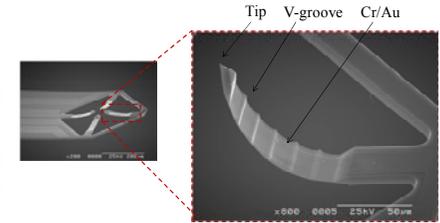


Figure 4. SEM image of the fabricated μ 4PP.

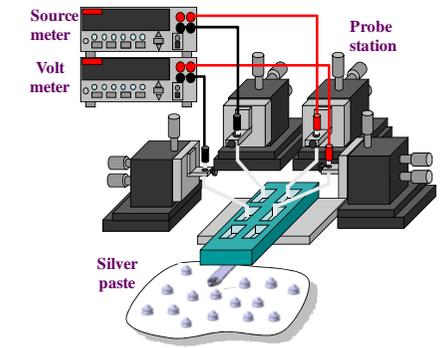


Figure 5. An experimental setup to measure electrical property

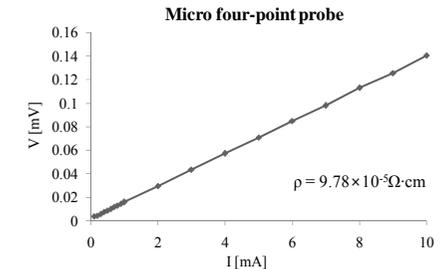


Figure 6. Resistivity measurement using the fabricated μ 4PP.