Write Characteristics of Silicon Resistive Probe

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Abstract

Probe storage is one of the strong candidates for future mobile storage device since it has potential of recording density over I Tb/in^2 with r/w speed over 100 Mbps. It also uses silicon-processing technology that suits the purpose of small form factor.

In this paper, write characteristics of resistive probe that can rotate the field direction of PZT by field-induced resistance changes in a small resistive region at the apex of the tip will be presented. Also, the relationship between the size of tip and theTo available write width is investigated for different source bias conditions. For this study, two-dimensional computer simulation (SILVACO^{TM}) was performed.

With optimum design, the width of the writing electric field can be smaller than 50nm

I. Introduction

The device SEM view and the schematic cross section of the resistive probe are shown Fig.1. A low-doped n-type region (a resistive region) is formed at the apex of p-type silicon tip and connected to the metal pads on the silicon body. Since the electrical resistivity of the the resistive region is much higher than high-doped regions, it can be considered as a small resistor formed at the apex of the tip. When the tip approaches the surface charge, the majority carriers in the resistive region are depleted or accumulated by the electric field. The depletion or accumulation of majority carriers alters the volume and the carried density of the conduction path in the resistive region, resulting in a resistance change.

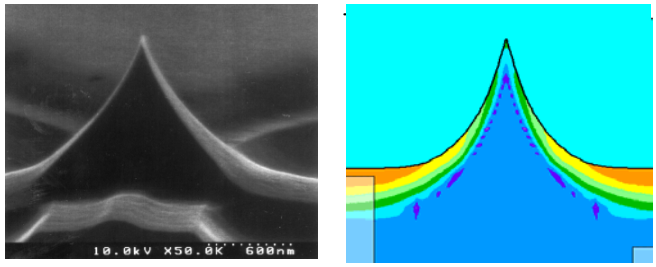

Fig.1 SEM image and schematic cross-section of resistive probe.

Ⅱ. Simulation

To investigate write characteristics of resistive probe, two-dimensional computer simulation(SILVACO^{TM}) was performed. Fig.2 shows simulation structure for this study. To obtain the narrower electric field width from at the apex of tip, shield structure was suggested. For the purpose of optimum design, the width of the writing electric field should be smaller than 50nm. Also, the width of the tip and tip distance (distance between PZT and tip) play an important role determining the width of the writing electric field. In this simulation, relationship between the size of tip and available write width is investigated for different drain bias conditions and tip distance.

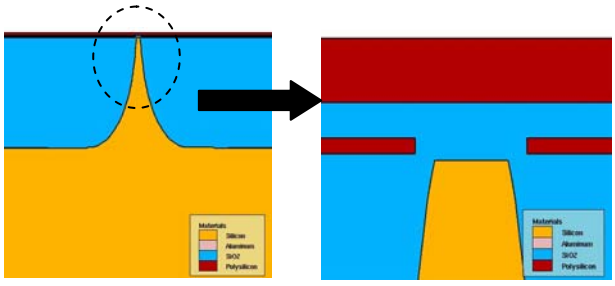

Fig 3. Simulation structure with shield which is made up of N^+ polysilicon

Ⅲ. Results

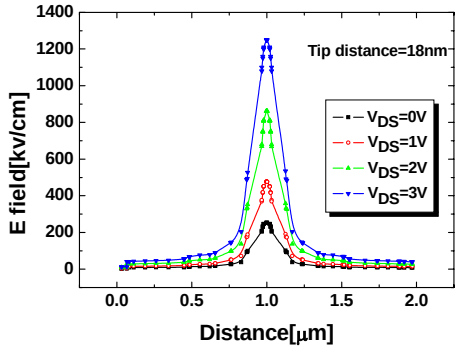

Fig 4-1The field distribution according to drain bias

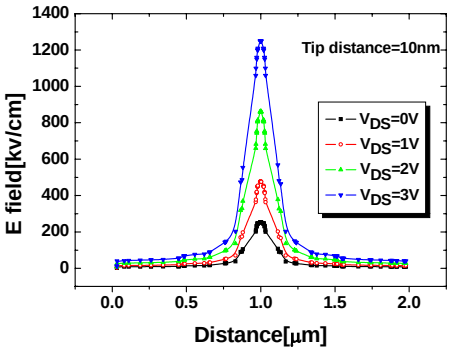

Fig 5-1 The field distribution according to drain bias

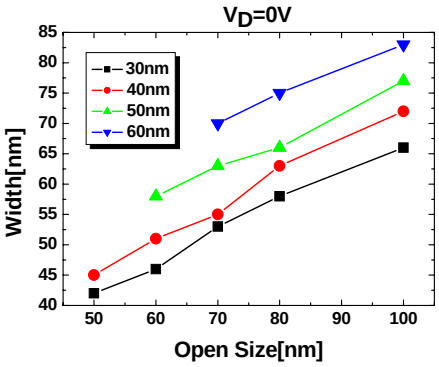

Fig.4-2 Tip distance=18nm

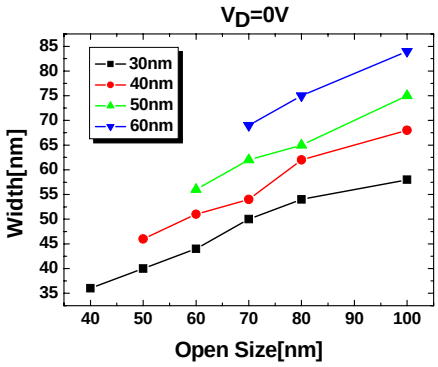

Fig 5.2 Tip distance=10nm

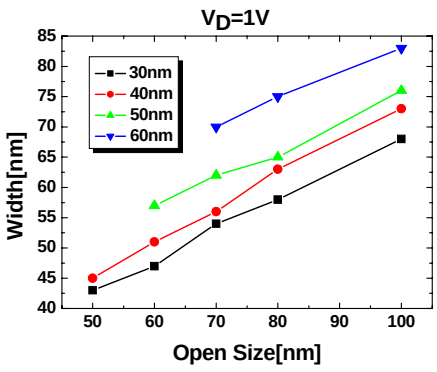

Fig.4-3 Tip distance=18nm

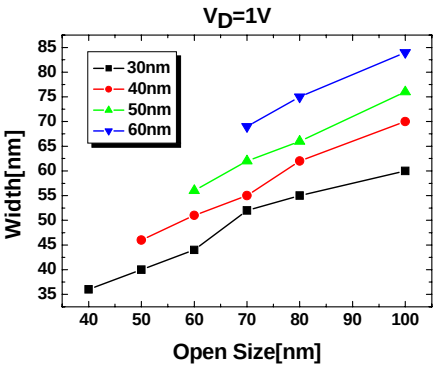

Fig 5-3 Tip distance=10nm

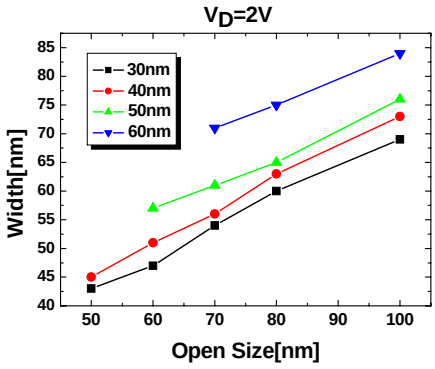

Fig 4-4 Tip distance=18nm

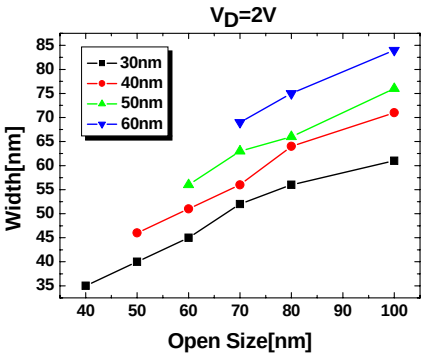

Fig 5-4 Tip distance=10nm

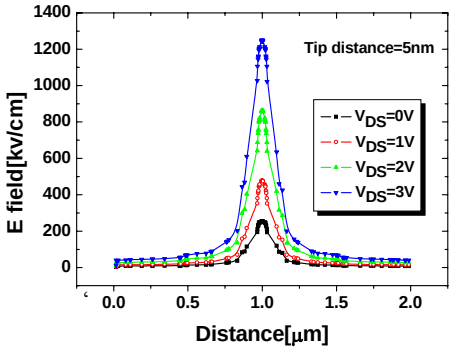

Fig 6-1The field distribution according to drain bias

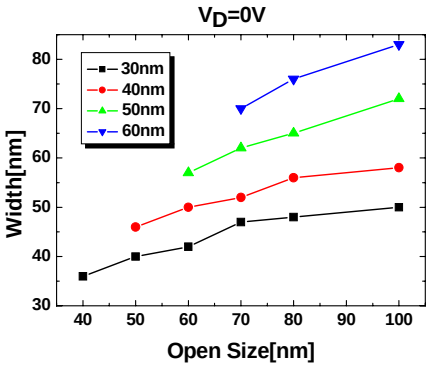

Fig. 6-2 Tip distance=5nm

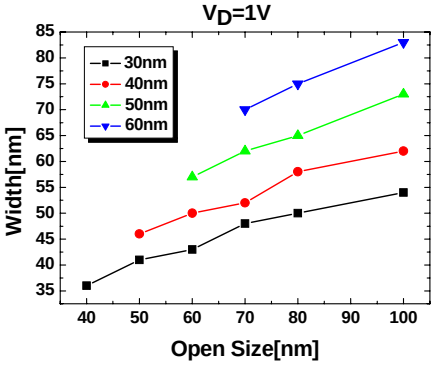

Fig.6-3 Tip distance=5nm

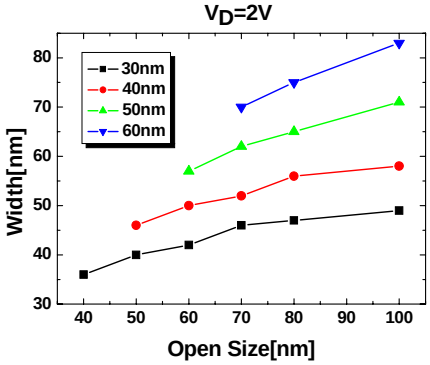

Fig 6-4 Tip distance=5nm

Fig. 4-1, 5-1, 6-1 shows the field distribution according to the drain bias condition when we vary tip distance. Fig 4-2,4-3, 4-4, 5-2, 5-3, 5-4, 6-2, 6-3, 6-4 shows the simulation results for different drain bias and tip distance. Writing width is defined the width for half value of maximum electric field. The simulation results show that writing width is mainly determined by the shied open size and tip size regardless of drain bias. When we see the simulation results, we can determine proper tip size, open size of shield and tip distance for the width of the writing electric field.

Ⅳ. Conclusion

In this paper, write characteristics of resistive probe that can rotate the field direction of PZT by field-induced resistance changes in a small resistive region at the apex of the tip was presented. Also , with optimum design, the width of the writing electric field can be smaller than 50nm.

Ⅴ. Acknowledgements

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Reference

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