Study on the characteristic of high precision thin film resistor

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Abstract: The characteristic of thin film resistor with low TCR(temperature coefficient of resistance) and high precision are studied. The thin film resistor for 1/4W was fabricated and characteristic of these resistors was investigated. The fabricated device had the thickness of 2.48 □ and the resistivity of 0.27 Ωmm. The electrical characteristic was evaluated by HP 4339B and 4284A instruments with HP 16339A. The profile of trimmed structure was also measured by non contact interferometer. The change of resistance and TCR increased with increasing roughness and resistance. To reduce the effect of stress annealing treatment was performed in the range of 563 to 623 K after trimming. The characteristic was improved after annealing. It is expected the fabricated device can be useful for high precision and low TCR. Fabricated thin film resistor has average deviation of resistance less than 0.35% and TCR within 60.60ppm/K.

Key words : precision thin film resistor, roughness, temperature coefficient resistance

INTRODUCTION

Thin film resistor with high precision is now extensively used for various purposes in the electronic industry [1]. Most thin film resistor, however, are subject to considerable variation of characteristic. This variation has been mainly considered to derive from resistive layer composition of thin film resistor. The variation of characteristic is not clarified yet in terms of manufacturing factors [2,3]. This study describes the results of analysis for the characteristic such as variation of tolerance of resistance and temperature coefficient of resistance (TCR) of thin film resistor during manufacturing process. To reduce the effect of stress characteristic of fabricated resistors was also investigated after annealing treatment.

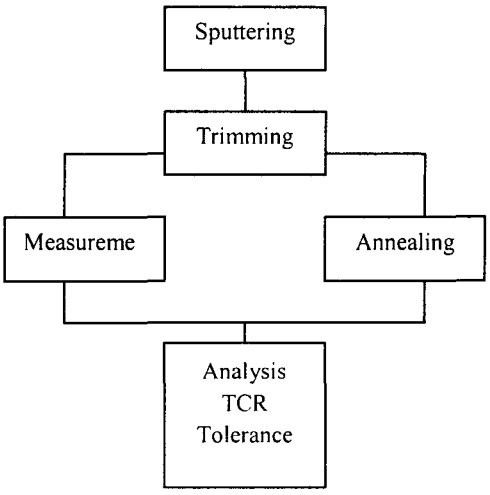

Fig.1 Experimental procedure.

EXPERIMENTAL PROCEDURE

The thin film resistors for 1/4W were prepared by sputtering and subjected to a trimming process as shown in Fig.1. Theses samples were fabricated with different average roughness ranged from 0.25 to 0.45 . Fig.2 shows the condition for preparing samples with different roughness. Thin film resistive layer had the thickness of 2.48 and the resistivity of 0.27Ωmm. These samples were trimmed ranged from 1kohm to 100kOhm as shown in Fig.3. Fig.4 shows the fabricated thin film resistor. The electrical characteristic was evaluated by HP 4339B and 4284A instruments with HP16339A. The profile of trimmed structure was also measured by non contact interferometer. To reduce the effect of stress annealing treatment was performed in the range of 563 to 623K after trimming. Characteristic was evaluated through fabricated resistors to be tested and also measured before and after annealing.

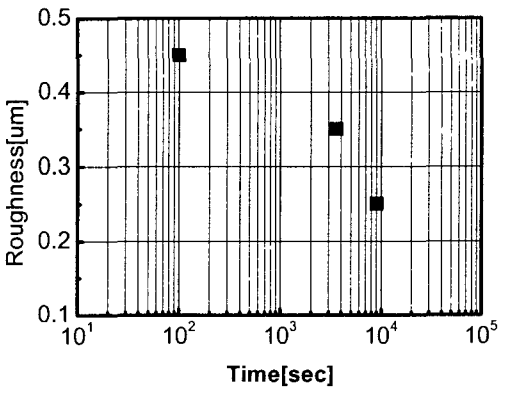

Fig.2 Variation of roughness with time.

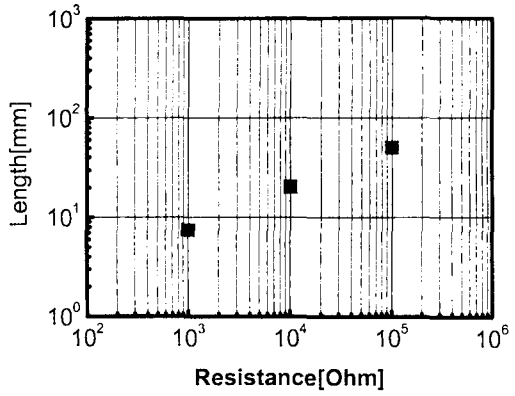

Fig.3 Trimmed length for resistance ranged from 1k to 100kohm.

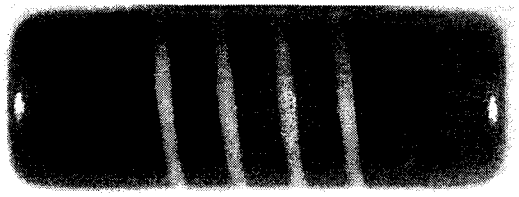

Fig.4 Fabricated thin film resistor.

RESULTS AND DISCUSSION

Fig.5 shows variation of resistance with roughness before annealing. Variation of resistance increases with increasing average roughness and resistance. Fig.6 shows variation of TCR with roughness before annealing. Variation of TCR increases with increasing roughness and resistance. It is observed samples with a higher resistance and average roughness have a higher variation of resistance and TCR. Resistance is proportional to trimmed length as shown in Fig.3. Higher resistance samples which have a longer trimmed length make a higher variation of characteristic.

Annealing is performed ranged from 563 to 623 K. Fig.7 shows variation of resistance with roughness after annealing at 593K.

Fig. 8 shows variation of TCR with roughness after annealing at 593K. The variation of resistance and TCR becomes small after annealing treatment was applied to resistor at 593K. As the result in annealing effect indicates it is reduced to variation of resistance less than 0.35% and TCR within 60.60ppm/K. On the other hand 100Kohm samples with a higher roughness 0.45um show a higher variation of resistance less than 0.38% and TCR within 70.56ppm/K. Thus improving effect derived from annealing can be considered to be related with stress reduction.

Fig.9 shows variation of resistance with roughness before and after annealing. Fig.10 shows variation of TCR with roughness before and after annealing. In the case of samples with a longer trimmed length and a higher average roughness show a higher variation of resistance and TCR. Annealing is expected to significantly reduce variation of resistance less than 0.35% and TCR within 60.60ppm/K in the case of samples ranged from average roughness from 0.25 to 0.35 um. The characteristic is significantly improved after annealing. It is expected the fabricated device can be useful for high precision and low TCR..

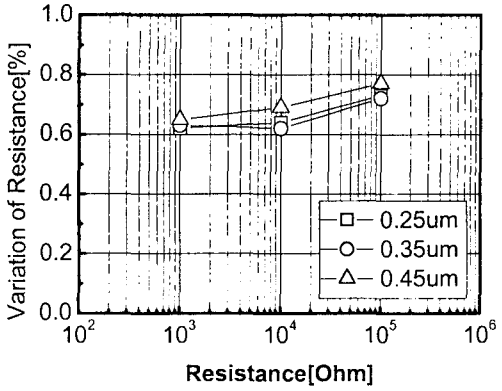

Fig.5 Variation of resistance with roughness before annealing.

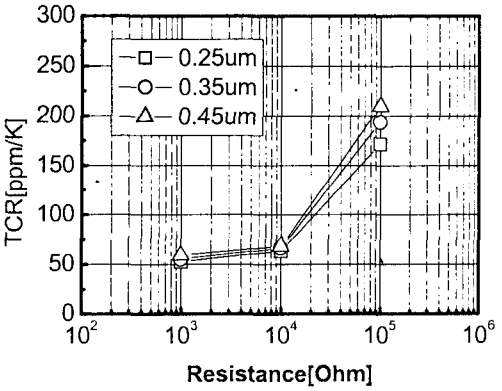

Fig.6 Variation of TCR with roughness before annealing.

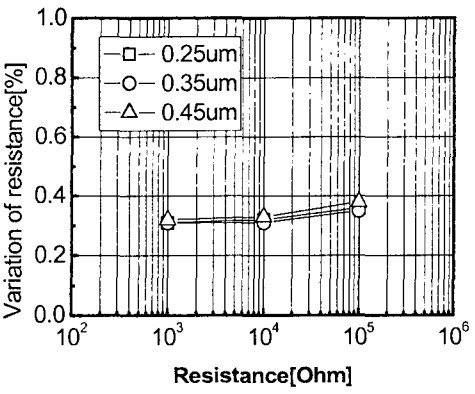

Fig.7 Variation of resistance with roughness after annealing at 593K.

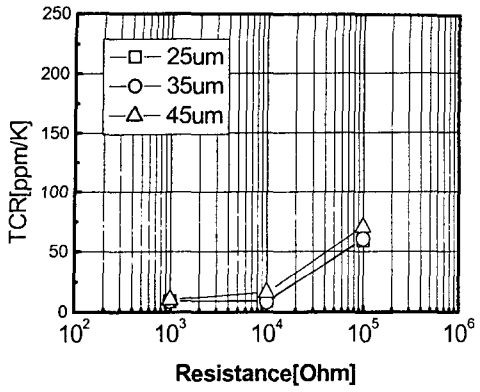

Fig. 8 Variation of TCR with roughness after annealing at 593K.

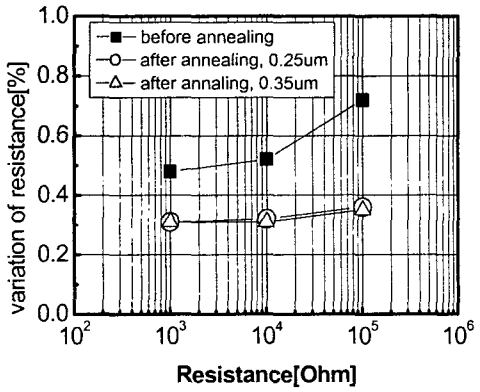

Fig.9 Comparison of resistance before and after annealing.

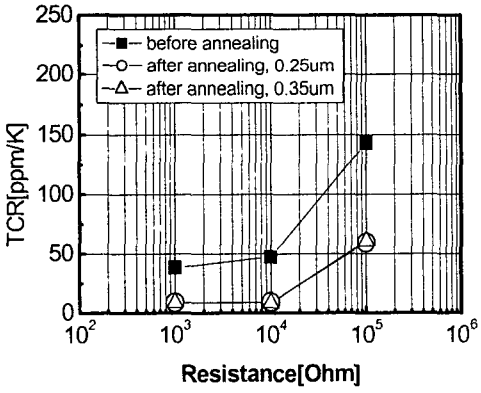

Fig.10 Comparison of TCR before and after annealing.

CONCLUSION

In this work, the characteristic of thin film resistor for 1/4W ranged from 1k to 100k ohm with low TCR(temperature coefficient of resistance) and high precision were studied.

1. The fabricated devices showed the resistance changed with variation of the surface roughness and trimming conditions. The change of resistance and TCR increased with increasing roughness and trimmed length.

2. Annealing treatment was performed to reduce stress in the range of 563 to 623 K after trimming. The characteristic was significantly improved after annealing. It is expected the fabricated device can be useful for high precision and low TCR. Fabricated thin film resistor ranged average roughness from 0.25 to 0.35um has average deviation of resistance less than 0.35% and TCR within 60.60ppm/K.

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