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Effect of Deposition Parameters on the Mechanical and Electrical Properties of ZnO Thin Films for SAW Sensor Applications

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Introduction

Surface acoustic wave (SAW) sensors are compact, low-power devices for monitoring gases such as NO_2, and their performance depends directly on the quality of the piezoelectric film. ZnO is a common choice because it can be deposited by magnetron sputtering at moderate temperature, but its crystallinity, electrical behavior and adhesion to the substrate are highly sensitive to the deposition atmosphere and substrate temperature. This work evaluates ZnO films sputtered on Si(100) under different gas compositions, temperatures and power sources, aiming at films suitable for SAW sensor fabrication.

Objectives

- To evaluate the effect of gas composition, substrate temperature and power source on ZnO films sputtered on Si(100) for SAW sensors.
- Deposit ZnO under Ar/O_2 and $Ar/O_2/N_2$ at 400 and 500 °C.
- Characterize structure, sheet resistance and adhesion.
- Select the condition combining good adhesion and electrical response.

Methodology

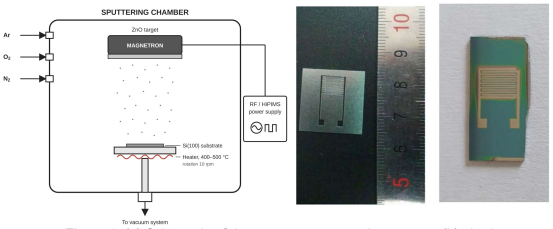


Figure 1. (a) Schematic of the magnetron sputtering reactor; (b) shadow mask and Ti interdigitated electrodes (IDT) on the ZnO/Si film.

ZnO sputtered on Si(100) from a ZnO target:

- Ar/O_2 40/20 or $Ar/O_2/N_2$ 40/10/10 sccm;
- 400 or 500 °C;
- 150 W (one sample HiPIMS 100 W);
- 7.5×10^{-2} Torr;
- 50 mm;
- 10 rpm;
- 60 min.

Results and discussion

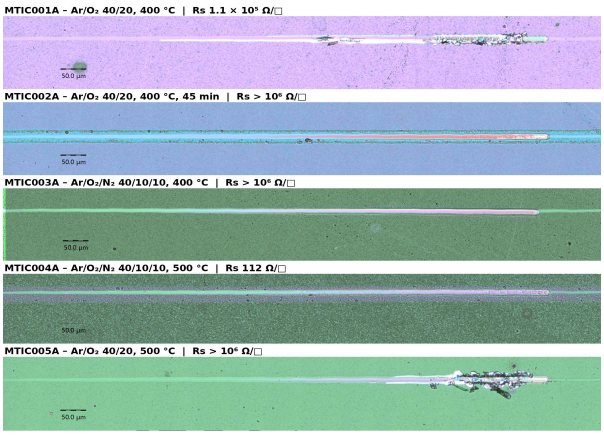


Figure 2. Scratch tracks of the ZnO films (load 0.03–1 N, left to right).

Table 1. Sheet resistance and scratch-test results of the ZnO films.

Sample	$Ar/O_2/N_2$ (sccm)	T (°C)	Rs (Ω/□)	AE onset (N)	Visible damage (N)	Failure mode
MTIC001A	40/20	400	1.1×10^5	0.19	0.53	Chipping, adhesive
MTIC002A	40/20	400*	$> 10^6$	0.26	from start	Damage along track
MTIC003A	40/10/10	400	$> 10^6$	—	—	No failure up to 1 N
MTIC004A	40/10/10	500	112	0.43	—	Minor cohesive
MTIC005A	40/20	500	$> 10^6$	0.36	0.69	Chipping, adhesive

Conclusions

- Only $Ar/O_2/N_2$ 40/10/10 at 500 °C gave measurable sheet resistance (112 Ω/□ RF; 22 Ω/□ HiPIMS); all other conditions exceeded 10^6 Ω/□.
- The same condition showed no delamination and only minor cohesive damage up to 1 N.
- $Ar/O_2/N_2$ 40/10/10 at 500 °C was selected for SAW device fabrication.

References and Acknowledgments

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