# Structural and electrical properties of the NiCr thin film resistors deposited at various temperatures on $SiO_2/Si$ substrate

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**Abstract**

The 200 nm thick- NiCr films grew on $SiO_2/Si$ substrates at various deposition temperatures by a dc magnetron co-sputtering technique were characterized for the variation of film texture. The resistivity of the films decreases with increasing deposition temperature and temperature coefficient of electrical resistance (TCR) varies from negative value to a positive one with increasing deposition temperature. The NiCr films deposited at 300°C exhibit 4 ppm/K being near zero TCR, resulting in TCR suitable for π-type attenuator applications.

## Introduction

Ni-Cr thin films have traditional applications in the microelectronics industry, particularly as thin film resistors in hybrid integrated circuits.[1-2] They have an advantage of high resistivity, low temperature coefficient of electrical resistance (TCR), and a good long-term stability.[3-4] Recently, according to the development of the mobile telecommunication, the study for π-type attenuator applications using NiCr thin films has been resumed.[3] Low TCR, which is constant electric resistance over a wide range of temperature, is required in microelectronics, especially in portable terminal and telecommunication devices for attaining high reliability.

In this study, NiCr (50 atomic% Cr) thin films were deposited on $SiO_2$ (600 nm)/Si substrates at various temperatures using magnetron co-sputtering technique.

## Experiment

The NiCr films were deposited at various temperatures by magnetron co-sputtering with Ni and Cr targets of 2-inch diameter. Oxidized silicon wafers of (100) orientation with an oxide thickness of 0.6 μm were used as substrates. The detailed deposition conditions of NiCr films by magnetron sputtering are summarized in a previous study.[3] The NiCr thin films for measurement of TCR were patterned using a shadow mask stabilized during deposition at high temperature. TCR of the samples was measured through a heating and cooling procedure in an air atmosphere from 25 to 120°C in a thermostatically controlled oven using a digital multimeter.

## Results and discussion

Figures 1(a), 1(b), and 1(c) show XRD patterns of the Ni, Cr, and NiCr thin films deposited at various temperatures, respectively.

Figure 2 shows SEM surface images of the NiCr films deposited at various temperatures. In the result, the grain shapes of the films have a close relationship with a growth orientation as a function of deposition temperature. The relationship between the resistivity and rms (root mean square) roughness of the films as a function of deposition temperature was shown in Fig. 3.

The resistivity of the films gradually decreases

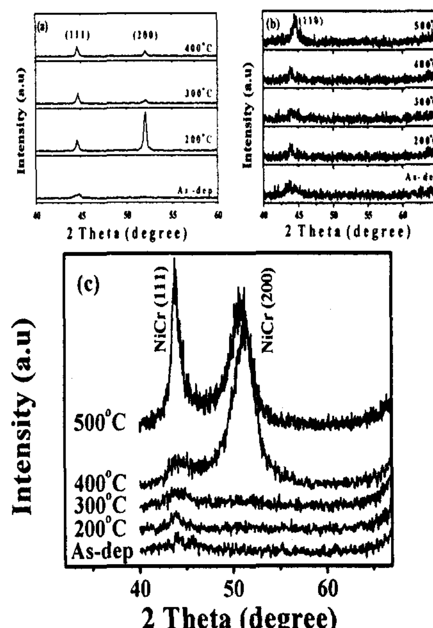


Fig. 1 XRD patterns of (a) the Ni films, (b) the Cr films, and (c) the NiCr films deposited at various temperatures.

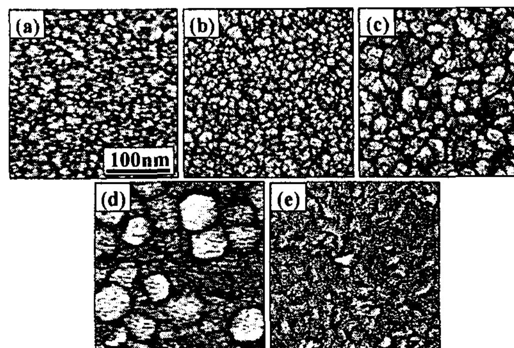


Fig. 2 SEM surface images of the NiCr films deposited at (a) room temperature, (b) 200°C, (c) 300°C, (d) 400°C, and (e) 500°C.

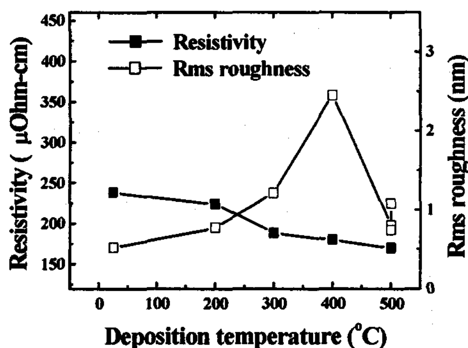


Fig. 3 The variation in the resistivity and the rms roughness of the NiCr films as a function of deposition temperature.

with increasing deposition temperature because the crystallinity of the films increases with increasing deposition temperature. In the result, the resistivity of the films does not depend on the variation of texture of the films. On the other hand, rms roughness of the films increases consistently with increasing deposition temperature because of an increase of crystallinity. This result may be related with the change of the texture in the NiCr films.

The variation in TCR and an irreversibility of the resistance as a function of deposition temperature was shown in Fig. 4. Films deposited at 300°C exhibit 4 ppm/K being near zero TCR, resulting in TCR suitable for π-type attenuator applications.

### Conclusions

The 200 nm thick-NiCr films were grown on $SiO_2/Si$ substrates at various deposition temperatures by dc magnetron co-sputtering technique. The texture of the NiCr films depends on the deposition temperature and

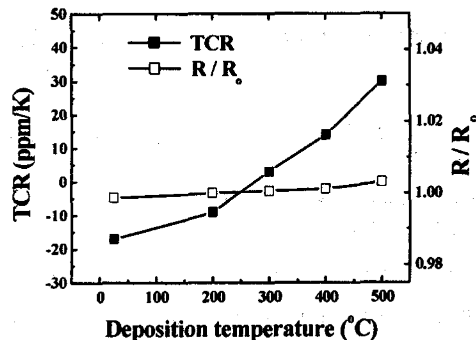


Fig. 4 The relationship between TCR and irreversibility ($R/R_o$) of the resistance as a function of deposition temperature.

was decided by that of the Ni films rather than Cr films at various deposition temperatures.

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