

# Ohmic Contact Recipe On $Ti_xCr_{2-x}O_3$ And Its Application To Temperature Dependent Hall Measurements

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**Abstract.** Ohmic contacts are formed on thin films with different compositions of  $Ti_xCr_{2-x}O_3$  ( $x=0.17, 0.41$  and  $1.07$ ). The ohmic contacts consists of 10 nm Ti and 50 nm Au, annealed at 1000 °C for 20 min in a  $N_2$  atmosphere. The ohmic contacts are suitable in a temperature range from  $T=35$  K to  $T=373$  K. Temperature Hall measurements are done, and the electrical properties of the TiCrO films, as function of composition are found. All layers are n-type, with  $10^{20}$   $cm^{-3}$  charge carrier density.

**Keywords:** TiCrO, ohmic contacts, semiconductor oxide, Hall study, mobility, charge carrier density.

**PACS:**

## INTRODUCTION

Recently, metal-oxide semiconductors have attracted attention for their scientific and technological applications. Among others, they make suitable sensors, which are capable of distinguishing ammonia, nitric oxide, carbon oxide, organic compounds, etc... [1, 5]. Their sensing capabilities consist of an abrupt change on their electrical conductivity on the presence of these gases. Among the novel metal-oxide semiconductors,  $Ti_xCr_{2-x}O_3$  (TiCrO) is one whose electrical properties and the formation of ohmic contacts on it have not been explored extensively.

The TiCrO semiconductor is a wide band gap semiconductor whose gap decreases from 3.5 to 2.7 as  $x$  changes from 0 to 1.6. This is the reason why, when the material is as-grown, it shows very poor conductivity and it is difficult to make good ohmic contacts on it.

In this paper, we study the electrical transport properties of annealed 10 nm Ti / 50 nm Au ohmic contacts deposited on thin films of  $Ti_xCr_{2-x}O_3$ , as function of temperature  $T$  and  $x$ . The annealing temperature was 1000 °C for 20 min, in a  $N_2$  atmosphere.

## SAMPLE GROWTH AND PREPARATION

The sample was grown by aerosol assisted chemical vapor deposition. An 0.8 MHz ultrasonic generator produced 1-5  $\mu m$  droplets aerosol, which was conducted to a chemical vapor deposition chamber. Ti-butoxide and Cr-petaneodinate were the chemical precursors, which were dissolved in isopropanol-acetic acid. Further details of the sample growth can be found in Ref. 1 and 2.

Using standard photolithographic techniques, as those described in Ref. 2, 10 nm Ti, followed by 50 nm Au, were deposited in a van der Pauw geometry. A schematic view of the samples can be observed in Fig. 1, where the ohmic contacts are shown with numbers 1, 2, 3 and 4. The samples were thermally annealed, in a  $N_2$  atmosphere. Several annealing temperatures were intended: 350 °C, 450 °C, 550 °C, 600 °C and 800 °C. All thermal treatments were 30 min, except the last one, which lasted 20 min. No conductivity was observed on any of the contacts, after these thermal treatments.

The samples were thermally treated once more, at 1000 °C, for 20 min, also in  $N_2$  environment. The conductivity between each pair of lateral contacts was tested, and they were all suitable ohmic contacts, at all temperatures between 35 K and 373 K.

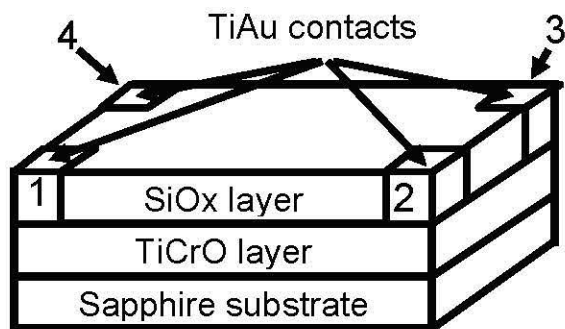


FIGURE 1. Schematic view of the sample structure

## TEMPERATURE DEPENDENT HALL STUDY

The samples were glued to the sample holder with Fixogum ©, to ensure good thermal contact [6]. In Fig. 1, the charge carrier density of all samples as function of T is shown.

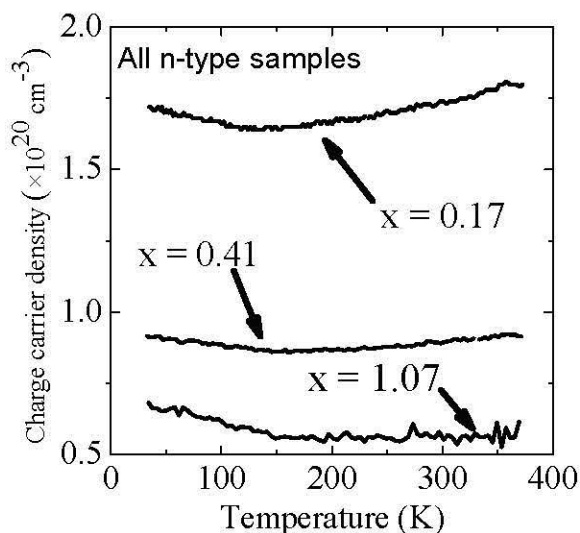


FIGURE 2. Temperature dependent Hall measurements of all three samples as function of temperature.

All samples were n-type at all temperatures. Samples with  $x = 0.17$  and  $0.41$  showed a thermally activated process, for temperatures above 200 K, with activation energies of 3.68 and 2.35 meV, respectively. The sample with  $x = 1.07$  did not show this thermally activated process, as the charge carrier density was practically constant above 200 K, with a value of  $5.5 \times 10^{19} \text{ cm}^{-3}$ . Clearly, the charge carrier density increased as the amount of Ti decreased.

Mobilities were practically constant, with no temperature dependence. Their values were 11, 26 and  $4 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ , for  $x = 0.17, 0.41$  and  $1.07$ , respectively. They did not show any clear relation with the stoichiometry of the sample.

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