Raman Spectroscopy on Metal Oxide Thin Films

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Application Note

Introduction

Our research field concerns the investigation of the structure-properties-reactivity interplay in transition-metal oxides. Complex transition-metal oxides are versatile materials with common use in various applications such as heterogeneous catalysts, gas sensors, and batteries components. The strongly interacting charge-spin and orbital ordering and the influence of the lattice yield unusual and useful properties. Therefore the investigation of these materials requires a thorough investigation of their structure, which can be partially assessed using Raman spectroscopy. Purity, phase-transition, lattice distortion and site occupancy are informations that might be obtained under ambient or controlled atmosphere and temperature. A home-built Raman spectroscopy setup was conceived for this purpose.

Experimental details

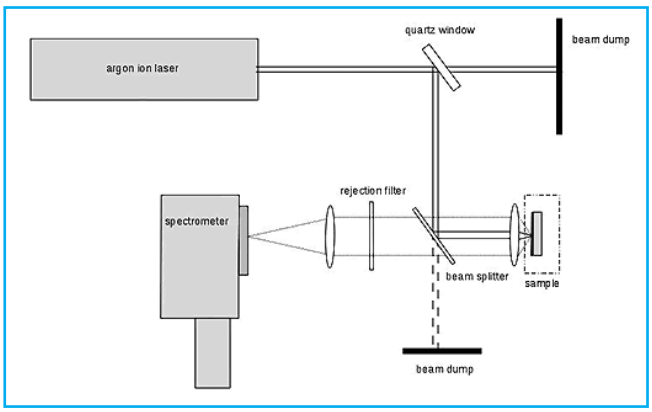

Figure 1. Raman spectroscopy setup

In this document, the doping of Co_3O_4 with Cr is given as illustrative example. Films, with a thickness of 300 nm, have been grown on steel substrates using the chemical vapour deposition method. Their investigation was performed using the Raman spectroscopy setup shown in fig.1. The λ = 514.5 nm line of an argon ion laser was used as excitation source and the detection of the Raman signal was done in the 180° configuration by a Shamrock SR-303i-A spectrograph combined to an iDus DU420A-BV CCD camera both from Andor Technology.

Results

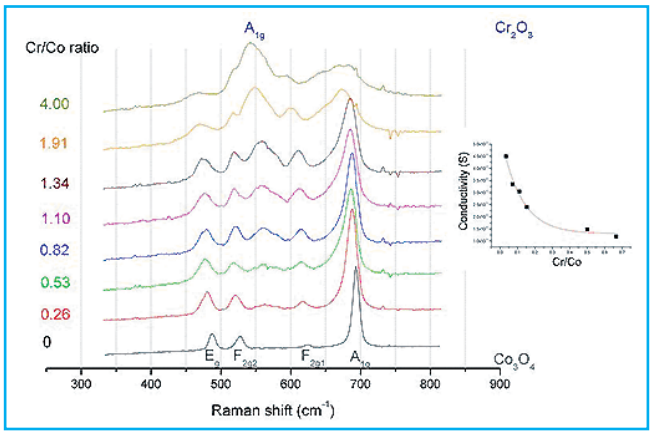

Figure 2. Raman spectra of Cr-doped Co_3O_4

The acquired spectra, displayed in fig. 2, evidence the evolution of the structure of Co_3O_4 when doping with chromium. Starting with the undoped cobalt oxide spinel structure, the four expected Raman active modes on the measured spectral range, A_{1g}, F_{2g1}, F_{2g2} and E_g, are respectively observed at 694, 625, 527 and 486 cm^{-1}. Upon increasing the concentration of Cr-doping we observe a broadening of the characteristic peaks and their shift to lower frequencies. These observations are the result of the increased structural disorder and a decrease in bond strength.

The Raman analysis reveals also a peak around 550 cm^{-1}, which is attributed to the A_{1g} vibration mode of the chromium oxide Cr_2O_3 structure, and betrays the presence of a second phase in the highly doped films, explaining the electrical behaviour shown as insert.

Conclusion

The insertion of chromium in the structure was partially successful but further optimization should be done to obtain single phase materials, which is a prerequisite to investigate the interplay between the structure, electrical transport properties, and the surface reactivity.

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