MOCVD GROWTH AND CHARACTERIZATION OF COBALT PHOSPHIDE THIN FILMS ON InP SUBSTRATES

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A great deal of attention has been recently devoted to a new class of electronic devices, known as spintronic devices, that involve manipulation of both the electron spin and charge. In this context, the search for new ferromagnetic materials is a major concern. One class of promising materials are transition metal pnictide compounds such as MnAs, MnSb or CoP.

This paper reports on the MOCVD growth and characterization of cobalt-phosphide thin films on (001) InP substrates. Cobalt phosphide thin films were grown in H_2 atmosphere with a low pressure Aixtron AIX200 reactor at a growth temperature of 550°C using $Co(Cp^{Me})_2$ (Cp^{Me} = methylciclo-pentadiene) and PH_3 as Co and P precursors respectively.

The cobalt precursor synthesis was carried out in a glove box filled with purified nitrogen according to the reaction

$$CoCl_2 + 2\,LiCp^{Me} \xrightarrow[T = -30°C]{THF} Co(Cp^{Me})_2 + 2\,LiCl$$

A series of specimens were grown at constant PH_3 flow rate of 300 sccm and different H_2 flow rates through Co bubbler for 1 hr and at a constant flow rate with different growth time.

Typical X-ray diffraction spectra (Fig.1) showed three weak film peaks at $2\theta_1 = 48.47°$, $2\theta_2 = 51.79°$ and $2\theta_3 = 52.22°$ that were assigned to the CoP(202), CoP(103) and CoP_2 (-311) Bragg reflections respectively. A strong preferential orientation of the crystallites was found, corresponding to Bragg planes parallel to the substrate surface (3° mosaic spread).

AFM micrographs of the film surface morphology evidenced grains of average in-plane diameter ≈ 80 nm and a surface roughness in the range 4 - 60 Å increasing with H_2 flow rate through the Co bubbler, deposition time and film thickness.

Typical wide scan surface XPS spectra (Fig. 2) displayed signals arising from Co, P, C and O. The presence of Co(II) was excluded, since its characteristic shake-up peaks were not observed. Despite the presence of oxygen, the formation of cobalt oxides could be unambiguously ruled out on the basis of BEs and Auger parameter values. On all sample surfaces, phosphate presence was evidenced (fig. 2, inset).

A representative XPS depth profile is displayed in Fig.3. Both phosphate and carbon peaks were reduced to noise level after a mild Ar^+ erosion, indicating that these species are limited to the outermost sample layers and that the Co precursor underwent a clean conversion into Co phosphides. Both the P/Co atomic ratio in the first 20 nm and the P/In ratio deep inside the substrate in Fig.3. are close to 2/1. By performing XPS depth profiles on InP substrates, preferential sputtering of P was observed yielding P/In ˜ 2 in agreement with previous reports, suggesting that the “real” P/Co atomic ratio in the first 20 nm in Fig.3 is ˜ 1, in agreement with the XRD results.

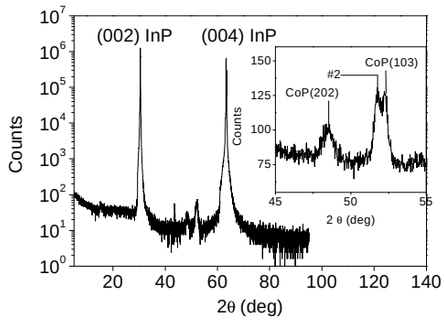

Figure 1. Typical X-ray diffraction spectrum (31 nm film thickness). The InP (002) and InP(004) substrate peaks are observed as well as three film peaks, shown in the inset.

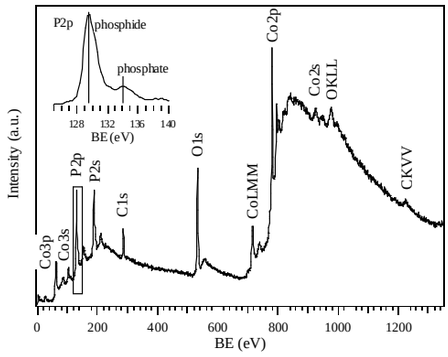

Figure 2. Typical surface XPS wide scan spectrum. The inset displays the P2p photopeak, evidencing the phosphide and phosphate components.

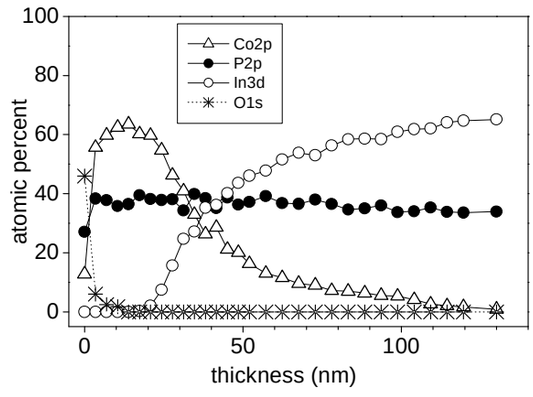

Figure 3. Representative XPS depth profile.