Analytical characterization of Y-Pd-B thin films deposited by magnetron sputtering

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The Y-Pd-B thin film system belongs to a larger group of cubic perovskites with the general formula RM_3X, where R and M are metals and X is B, C or N. They are drawing a lot attention lately because of their interesting properties [1,2]. Theoretical calculations indicate the RM_3X compounds may possess an unusual combination of metallic and ceramic properties due to interleaving of high and low electron density layers [3].

In this work, a Y-Pd-B thin film has been successfully deposited without intentional heating the substrate. Bright field image shows that the film is dense with small grains. The crystals grow horizontally and continuously from the substrate to the top of the film. This indicates that there is no disturbance in the crystallization process (figure 1.a). Phase identification by electron diffraction shows ring patterns which can be identified as belonging to the YPd_3 phase (JCPDS: 17-0059) (figure 1.b).

Owing to the differences in elemental weight, two methods were used to qualitatively investigate the presence of boron, palladium and yttrium. STEM HAADF EDX line scan was performed to see the concentration distribution of yttrium and palladium. Figure 2.a shows that the yttrium and palladium are distributed homogenously. Light elements as boron were identified by EFTEM elemental maps. These images show that boron is also distributed homogeneously in whole film (figure 2.b and c).

Additionally, series of electron spectrum imaging (ESI) images were obtained from the film. From these ESI series, electron energy loss spectra can be extracted from any given area of the sample and later on, a qualitative and quantitative analysis can be performed [4,5].

Figure 3.a shows bright field images from the areas where the ESI series have been taken as well as the extracted spectra. The spectra (figure 3.b) clearly show the presence of boron in both rectangular areas. Quantitative analyses were also performed on the extracted spectra. The Pd/B ratios taken from two thinner areas of the sample were 2.62 and 3.47 respectively, which indicates that the overall composition corresponds to YPd_3B (figure 3.c).

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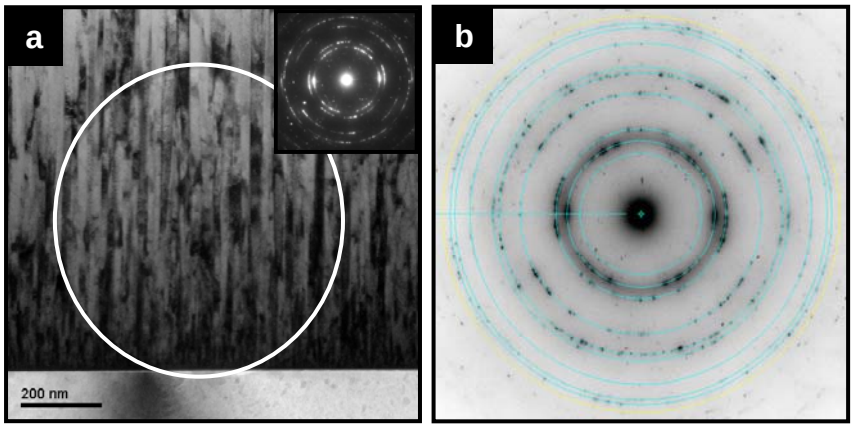

Figure 1. (a) Bright field image and electron diffraction (inset) showing the microstructure of the film which is dense and contains fiber-like grains. (b) Ring pattern obtained by electron diffraction. The pattern was identified as belonging to the YPd_3 phase (JCPDS:17-0059).

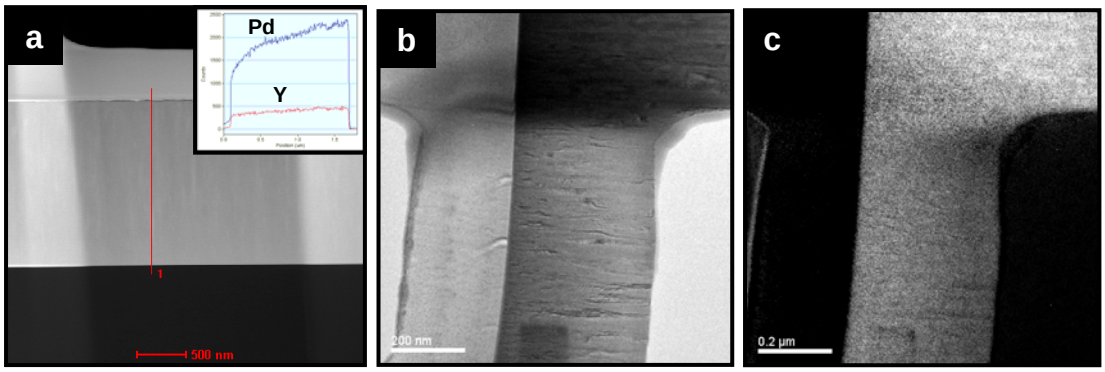

Figure 2. (a) STEM HAADF EDX line scan and intensity profiles (inset) show the homogenous concentration distribution of yttrium (red) and palladium (blue). (b) EFTEM bright field images and (c) boron elemental maps show the homogenous distribution of boron in the whole film.

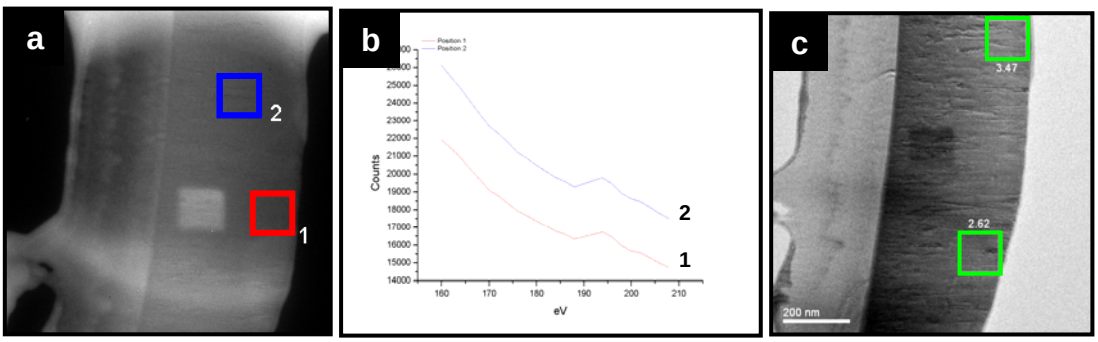

Figure 3. (a) Bright field image of two areas under investigation, from which ESI series were obtained. (b) The spectra which were extracted from the series of 25 images with ∂E= 2eV and an increment of 2 eV by integrating over the rectangular areas indicated in (a). (c) In two thin areas a quantitative analysis has been performed and shows that the Pd/B ratios are close to the YPd_3B phase.

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