
Monograph:
Shepley, P orcid.org/0000-0003-1240-593X (2020) Growth of (111) oriented thin film platinum by room temperature sputtering. Report. Materials from the Royce Deposition System (5). University of Leeds

10.48785/100/84

Growth of (111) oriented thin film platinum by room temperature sputtering

P.M. Shepley

This application note describes the growth Pt thin films in the Royce Deposition System. X-ray reflectivity and diffraction shows that these sputtered Pt thin films have low surface roughness and are (111) textured. These properties are desirable for the growth of Pt in magnetic multilayers and as seed layers for other materials.

1 Introduction

Pt is an important component in some magnetic multilayers, for example $[Pt/Co/Ir]_n$, which has perpendicular magnetic anisotropy and can host magnetic skyrmions[1, 2]. At the interface between Pt and Co (or a Co-based alloy e.g. CoB, CoFe or CoFeB) the Pt promotes perpendicular magnetic anisotropy (PMA)[3, 4] in the Co and is important for producing a Dzyaloshinskii-Moriya interaction (DMI)[5–7] in the films. The thin layers of different materials in these types of thin films need to have low roughness in to allow interface effects, such as PMA and DMI to emerge.

Pt thin films can be used as electrodes and seed layers for some polycrystalline oxide thin films: the lattice constant of Pt matches well to some perovskites such as $SrTiO_3$, $PbTiO_3$ and $BiFeO_3$[8–10]. Pt seed layers for this application should be textured, with low roughness and large grain size.

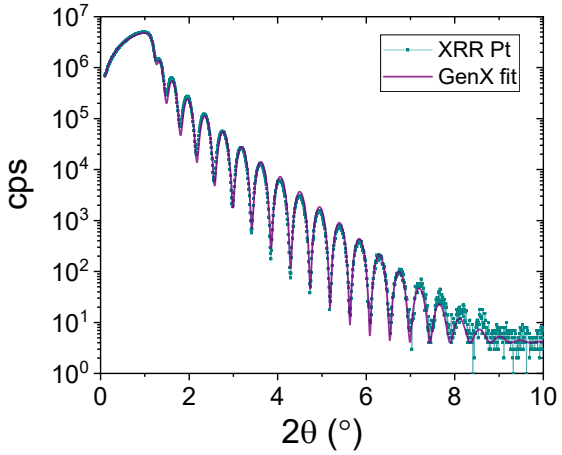

Figure 1: X-ray reflectivity data of a Pt thin film grown in the sputtering chamber. The fitted thickness was 192 Å.

2 Growth

A Pt film was deposited by dc magnetron sputtering in the Royce Deposition System. The magnetrons are mounted in a ring below the substrate with source-substrate distances of 134 mm. A liquid nitrogen shroud was used to bring the base pressure of the system down to 4.6 $x10^{-10}$ mbar. The Ar gas was flowed through the chamber at 10 sccm with the gate valve to the turbo pump throttled to 43 % to give an equilibrium process pressure of $3.6x10^{-3}$ mbar. Pt was deposited onto a glass substrate at room temperature (21°C), at a rate of 0.67 Å/s for 286 s from a magnetron at 30 W.

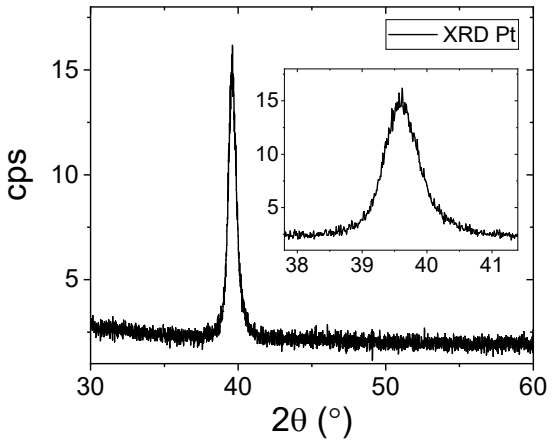

Figure 2: X-ray diffraction data of a Pt thin film grown in the sputtering chamber. The inset shows a enlarged plot of the (111) peak.

3 Properties

The Pt thin film was measured using X-ray reflectivity (XRR) and X-ray diffraction (XRD) in a Bruker

GenX fitting parameter	Value
Thickness - Pt (Å)	192
Density - Pt (% of bulk)	100
Roughness - Pt (Å)	4
Roughness - glass (Å)	4

Table 1: Structural parameters obtained by fitting XRR data with GenX.

D8 diffractometer in Bragg-Brantano geometry with a $Cu_{K\alpha}$ source (λ = 1.5406 Å).

Figure 1 shows the XRR of the Pt thin film. The XRR data was fitted with GenX [11]. The fit gave a Pt film thickness of 192 Å and an average surface roughness of 4 Å. The glass substrate also has a roughness of 4 Å. The fitted parameters are shown in Table 1.

Figure 2 shows the XRD of the Pt thin film. Only the (111) peak is present in the XRD spectrum, showing that the Pt film has a (111) texture. The Scherrer equation was used to estimate for the size of Pt crystallites in the film. The equation for crystallite size is given by

$$D = \frac{K\lambda}{FWHM(2\theta)\cos\theta}, \tag{1}$$

where θ is the Bragg angle of the peak in radians, $FWHM(2\theta)$ is the full width half maximum in 2θ, λ is the wavelength of the incident X-rays and K is a dimensionless parameter relating to the shape of the crystallites [12]. The Scherrer equation gives a crystallite size of $D = 124 \pm 1$ Å.

The Royce Deposition System can produce good quality thin films of sputtered polycrystalline Pt. The film roughness is the same as the roughness of the substrate (4 Å) and is of a similar scale to the lattice parameter of the material (3.92 Å). The estimated crystallite size (124 Å) is close to the thickness of the film (192 Å) and the film has a (111) texture. These characteristics are desirable for sputtered Pt used in magnetic multilayers and as seed layers for some perovskite oxides.

4 Further Information

The Royce Deposition System is a multichamber, multitechnique thin film deposition tool based at the University of Leeds as part of the Henry Royce Institute. Materials from the Royce Deposition System are available as a facility service and for collaborations.

Sample growth ID: MET20190613_01

References

1. P. M. Shepley *et al.*, *Physical Review B* **97**, 134417, arXiv: 1703.05749 (Apr. 2018).
2. K. Zeissler *et al.*, *Scientific Reports* **7**, 15125, arXiv: 1706.01065 (Dec. 2017).
3. J. Geissler *et al.*, *Physical Review B* **65**, 020405 (Dec. 2001).
4. N. Nakajima *et al.*, *Physical Review Letters* **81**, 5229–5232 (1998).
5. A. Hrabec *et al.*, *Physical Review B* **90**, 020402(R) (2014).
6. R. A. Khan *et al.*, *Applied Physics Letters* **109**, 132404, arXiv: 1607.06405 (Sept. 2016).
7. A. W. Wells *et al.*, *Physical Review B* **95**, 1–8, arXiv: 1608.03826 (2017).
8. S. Krupanidhi *et al.*, *Thin Solid Films* **249**, 100–108 (Sept. 1994).
9. A. Pignolet *et al.*, *Journal of Physics D: Applied Physics* **24**, 619–621 (Apr. 1991).
10. A. Srivastava *et al.*, *Journal of Applied Physics* **105** (2009).
11. M. Björck *et al.*, *Journal of Applied Crystallography* **40**, 1174–1178 (2007).
12. J. I. Langford *et al.*, *Journal of Applied Crystallography* **11**, 102–113 (1978).