
Monograph:
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Growth of E-beam evaporated platinum

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This application note describes the epitaxial growth of electron beam evaporated platinum in the Royce Institute thin films deposition facility and presents data demonstrating the material's properties.

1 Introduction

Platinum is used frequently within spintronics research. In particular, its high spin orbit coupling makes it the optimum material for studying spin-charge conversion[1] in addition to interfacial magnetic phenomena.[2] Therefore, the growth of high quality platinum films is crucial across a wide area of physics research. Within this application note, we provide a recipe for the growth of a smooth, highly textured platinum film which orders in the (111) orientation out of plane.

2 Growth

Platinum is able to order on various substrates.[3] In this application note, the procedure used by Mihai et al has been adopted.[4] 8×8 mm pieces of (0001) oriented Al_2O_3 were sonicated in acetone and isopropanol. Once loaded into the Royce prep chamber, substrates were out-gassed and annealed at 800 °C for 4 hours. Once at room temperature, sample plates were transferred into the Royce organics chamber. Substrates were then heated back to 800 °C at 10 °C/minute. Additionally, the platinum E-beam source was first ramped slowly up to a 10 kV acceleration voltage. Following this, the emission current was ramped to 115 mA, pausing every 10 mA for the source to warm, out-gas and for the vacuum to recover. In this instance, a rate of 0.7 Å/s was achieved in a working pressure of 2.3×10^{-7} mbar. The substrate temperature was ramped down to 500 °C at 5 °C/min. The platinum film was then grown using a 90 °/s substrate rotation until a film of thickness ∼50 nm was observed on the crystal rate monitor. Once the film was grown, the substrate was held at 500 °C until the platinum source was de-energised, cool and the vacuum recovered.

3 Properties

Structural characterisation was obtained using X-ray reflectivity (XRR) and X-ray diffraction (XRD) techniques. Figure 1 shows the XRR data taken of the thin platinum film. GenX [5] was then used to fit the data, yielding the structural parameters shown in Table 1.

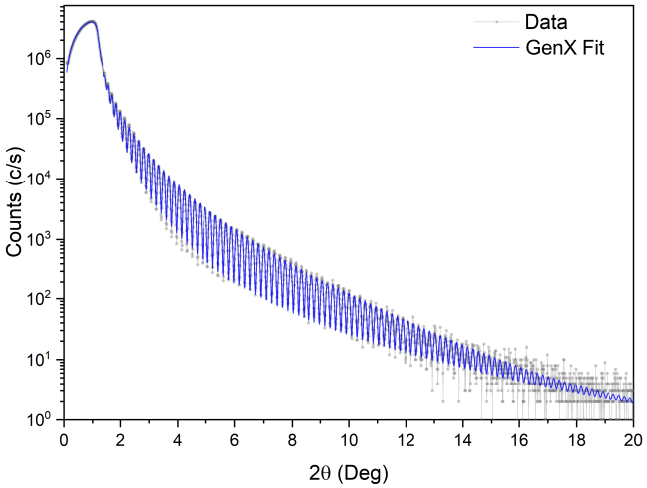

Figure 1: X-ray reflectivity data of a platinum thin film grown in the organics evaporation chamber. The fitted thickness was 30 nm.

GenX fitting parameter	Value
Thickness (nm)	46.7±0.1
Density (% of bulk)	102.80±0.01
RMS Roughness (Å)	0.94±0.01

Table 1: Structural parameters obtained through the fitting of XRR data with GenX.

Kiessig fringes are observed beyond 16 °, implying minimal surface roughness. This is supported by the GenX fit which yields an rms roughness below 1 Åwith expected values for the thickness and density. Figure 2 shows the out of plane X-ray diffraction data obtained for this film. Both the Pt (111) and Al_2O_3(0001) are observed. Fitting the Pt (111) Bragg peak to the Scherrer formula yields an out of plane grain size of 43±0.4 nm. It should be noted that the Pt Bragg peak has been artificially broadened by the presence of

both Cu-kα and Cu-kβ emission, seen as a doublet for the Al_2O_3 (0001) peak. Therefore, the true grain size will be closer the total film thickness.

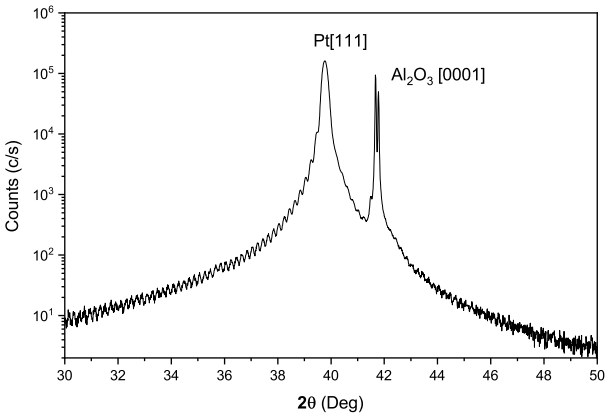

Figure 2: Out of plane X-ray diffraction data of a platinum thin film grown in the organics evaporation chamber. The Pt (111) and Al_2O_3(0001) Bragg diffraction peaks can be observed, in addition to Pendellosung fringes implying very smooth and flat film surfaces. The out of plane grain size measured for this film was 43 ± 0.4 nm.

References

1. E. Saitoh *et al.*, *Citation: Appl. Phys. Lett. Journal of Applied Physics Applied Physics Letters Applied Physics Letters Applied Physics Letters* **881**, 182509–103913 (2006).
2. K. Zeissler *et al.*, *Nature Nanotechnology* **13**, 1161–1166 (Dec. 2018).
3. B. M. Lairson *et al.*, “Epitaxial Pt(OOl), Pt(1 IO), and Pt(l11) films on MgO(001), MgO(1 IO), MgO(l1 I), and A1203(OO01)”, tech. rep. 12.
4. A. P. Mihai *et al.*, *Applied Physics Letters* **103**, 262401 (2013).
5. M. Björck *et al.*, *Journal of Applied Crystallography* **40**, 1174–1178 (2007).