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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]  $8 \times 8$  mm pieces of (0001) oriented  $\text{Al}_2\text{O}_3$  were sonicated in acetone and isopropanol. Once loaded into the Royce prep chamber, substrates were out-gassed and annealed at  $800^\circ\text{C}$  for 4 hours. Once at room temperature, sample plates were transferred into the Royce organics chamber. Substrates were then heated back to  $800^\circ\text{C}$  at  $10^\circ\text{C}/\text{minute}$ . 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  $0.7 \text{ \AA}/\text{s}$  was achieved in a working pressure of  $2.3 \times 10^{-7}$  mbar. The substrate temperature was ramped down to  $500^\circ\text{C}$  at  $5^\circ\text{C}/\text{min}$ . The platinum film was then grown using a  $90^\circ/\text{s}$  substrate rotation until a film of thickness  $\sim 50$  nm was observed on the crystal rate monitor. Once the film was grown, the substrate was held at  $500^\circ\text{C}$  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.

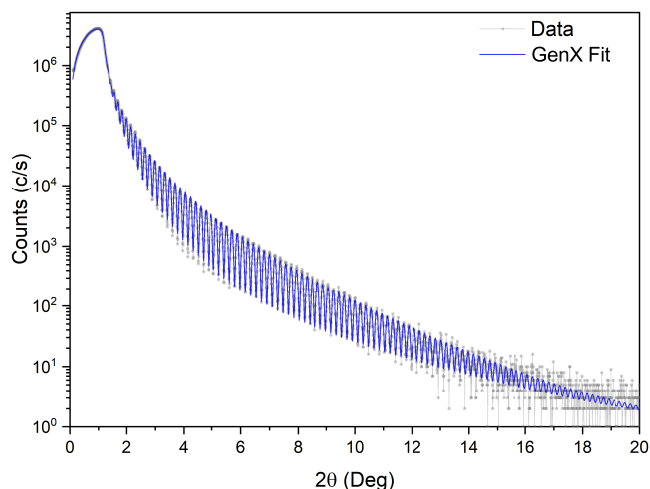


Figure 1: X-ray reflectivity data of a platinum thin film grown in the organics evaporation chamber. The fitted thickness was 30 nm.

GenX fitting parameter	Value
Thickness ( nm )	$46.7 \pm 0.1$
Density ( % of bulk )	$102.80 \pm 0.01$
RMS Roughness ( $\text{\AA}$ )	$0.94 \pm 0.01$

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

Kiessig fringes are observed beyond  $16^\circ$ , implying minimal surface roughness. This is supported by the GenX fit which yields an rms roughness below  $1 \text{ \AA}$  with 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  $\text{Al}_2\text{O}_3$  (0001) are observed. Fitting the Pt (111) Bragg peak to the Scherrer formula yields an out of plane grain size of  $43 \pm 0.4$  nm. It should be noted that the Pt Bragg peak has been artificially broadened by the presence of

both Cu- $\alpha$  and Cu- $\beta$  emission, seen as a doublet for the Al<sub>2</sub>O<sub>3</sub> (0001) peak. Therefore, the true grain size will be closer the total film thickness.

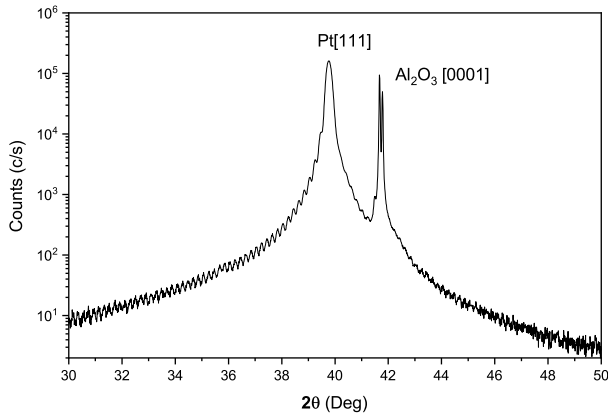


Figure 2: Out of plane X-ray diffraction data of a platinum thin film grown in the organics evaporation chamber. The Pt (111) and Al<sub>2</sub>O<sub>3</sub>(0001) Bragg diffraction peaks can be observed, in addition to Pendellosung fringes implying very smooth and flat film surfaces. The out of plane grain size measured for this film was  $43 \pm 0.4$  nm.

## References

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