Balancing of residual stress in thin film iridium by utilizing chromium as an underlayer


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INTRODUCTION

The demand for X-ray optics increases and so do their performance requirements. Iridium (Ir) thin film coatings have proven to be very robust and exhibit excellent reflective properties within the X-ray regime. However, the residual stress in Ir thin films is high and studies show that thin film Ir coatings with a thickness of 10–30 nm exhibit residual compressive stress as illustrated in Figure 1.

EXPERIMENTAL

Double-sided polished diced silicon substrates with dimensions 70 mm × 10 mm × 0.775 mm (L × W × H) were used to deposit the chromium (Cr) and Ir films on. The thin film depositions were carried out in the Athena dedicated coating facility installed at cosine. The list of samples is presented in Table 1. Samples denoted with csxxxx were used for AFM and XRR and samples denoted with sxxxx were used for stylus profilometry.

X-RAY REFLECTOMETRY

To describe the 8.048 keV and 1.487 keV XRR data of Cr/Ir bilayer thin films, we use models composed of Si/SiO₂/Cr/Ir and Si/SiO₂/Cr/Ir/CHO, respectively. The best-fit parameters are shown in Table 2. The best-fit Cr thicknesses and Ir thicknesses derived at 8.048 keV and 1.487 keV are in good agreement. The best-fit Cr roughnesses are consistently higher than the best-fit Ir roughnesses as presented in Figure 3. Furthermore, the best-fit roughnesses of both Cr and Ir are increasing with increasing best-fit Cr thickness. The best-fit thicknesses of the hydrocarbon overlayer modelled at 1.487 keV are ~1.5 nm. The best-fits are shown in Figures 4 and 5.

Table 1 – AFM was used to image the surface of Cr/Ir coatings in three positions. The scan size is 1x1 μm².

Table 2 – Best-fit parameters of XRR data acquired for the single layer films of Cr.

STYLUS PROFILOMETRY

The residual stress of the thin films was calculated using Stoney’s equation. The residual stress exhibited by the 10 nm Ir film is counterbalanced by a Cr film with a thickness of approximately 13 nm, see Figure 6. The buckling delamination of a 80 nm Ir film is shown in Figure 7.

CONCLUSIONS

Cr films of varying thicknesses were deposited underneath 10 nm Ir films, and we identified that a Cr film thickness of 13 nm is suitable to balance the stress of the Ir film. We also identified that a single layer Ir film with a thickness of 80 nm exhibited an excessive stress level resulting in a buckling delamination of the film.

REFERENCES

1. D. M. Broadway et al. 2015
2. S. Massahi et al. 2020