X-ray reflectivity measurements at chromium-iridium tri-layer coatings

Veronika Stehlíková [1,2], Tobias Schäfer [3], Manfred Stollenwerk [3], Thorsten Döhring [3], Peter Friedrich [1], Vadim Burwitz [1]

[1] Max-Planck Institute for extraterrestrial Physics, D-85748 Garching, Germany

[2] Czech Technical University in Prague, CZ-16627 Prague 6, Czech Republic

[3] TH Aschaffenburg - University of Applied Sciences, D-63743 Aschaffenburg, Germany

Summary

Aschaffenburg University and the Czech Technical University in Prague jointly developed stress compensated chromium-iridium coatings, with an outlook for their usage in astronomical applications. The samples of combined layers of chromium and iridium were tested at the Panter X-ray facility and their expected properties were proved. As a next step, environmental stability tests and the preparation of optical modules are planned.

Encouraged by the positive results of the thin overlayer method approach, also experiments with other available materials are in the scope of our interest. For the nearest future it could be combination with manganese or tungsten, which is also presented in this poster.

Panter tests in numbers

Tests were performed using single spectral lines provided by different elements. During the measurement, depending on the strength of the source, about 3k – 5k of single incidents were caught by the detector, filtered and corrected for the uncertainties of the measurement. Part of the results are listed in the tables.

We focused at the interesting energies around the energy gaps and on time feasibility of runs.

30 nm Ir on 60 nm Cr, bilayer, TR – theoretical, MR measured values, ΔR uncertainty

Energy (eV)	TR (%)	MR (%)	ΔR (%)
280	89.59	90.55	2.53
540	87.96	92.80	3.69
940	88.14	89.56	3.69
1500	87.77	86.41	2.31
1780	86.38	89.62	3.08
2120	45.49	64	2.21

6 nm Cr on 30 nm Ir on 60 nm Cr, trilayer, TR – theoretical, MR measured values, ΔR uncertainty

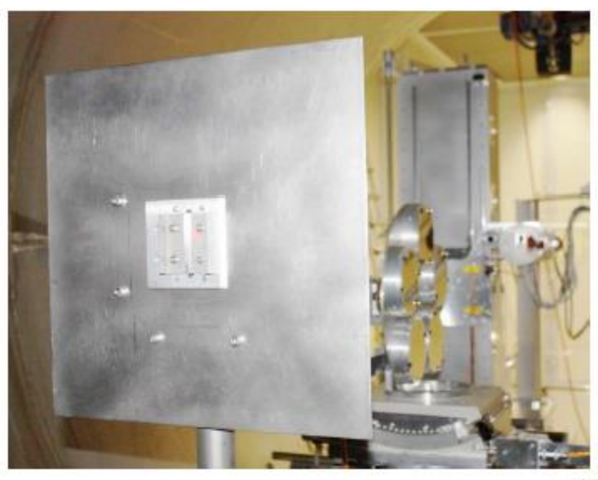
Energy (eV)	TR (%)	MR (%)	ΔR (%)
280	96.95	97.22	6.20
540	95.22	93.24	5.70
940	82.89	87.07	2.35
1500	87.89	88.36	2.25
1780	88.77	93.33	3.31
2120	89.24	85.11	2.37

4 nm Cr on 30 nm Ir on 60 nm Cr, trilayer, TR – theoretical, MR measured values, ΔR uncertainity; Cu L-line was skipped

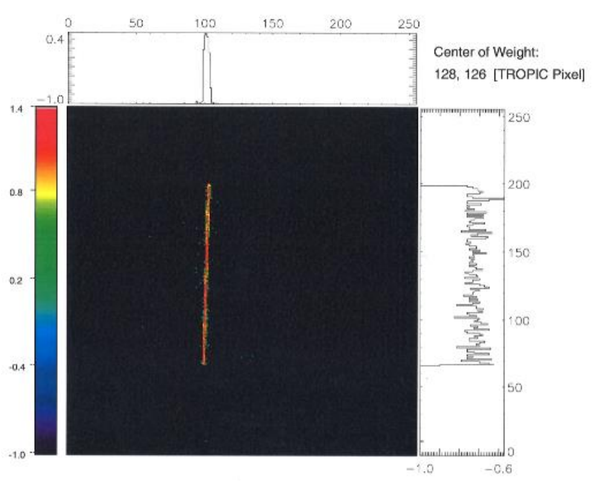
Energy (eV)	TR (%)	MR (%)	ΔR (%)
280	97.08	95.93	2.66
540	94.39	91.83	3.29
940	-	-	-
1500	88.43	87.57	2.45
1780	89.10	90.00	2.76
2120	88.95	83.55	2.50

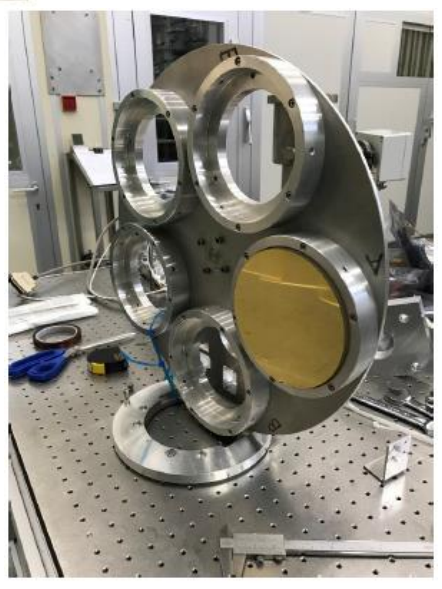
Set-up for reflectivity measurements

Target	Energy (keV)	Wavelength (nm)
C-K	0.28	4.43
Cu-L	0.93	1.33
Al-K	1.49	0.83
Au-M	2.14	0.58
Ag-L	2.98	0.42
Cr-K	5.41	0.23
Fe-K	6.40	0.19
Cu-K	8.04	0.15



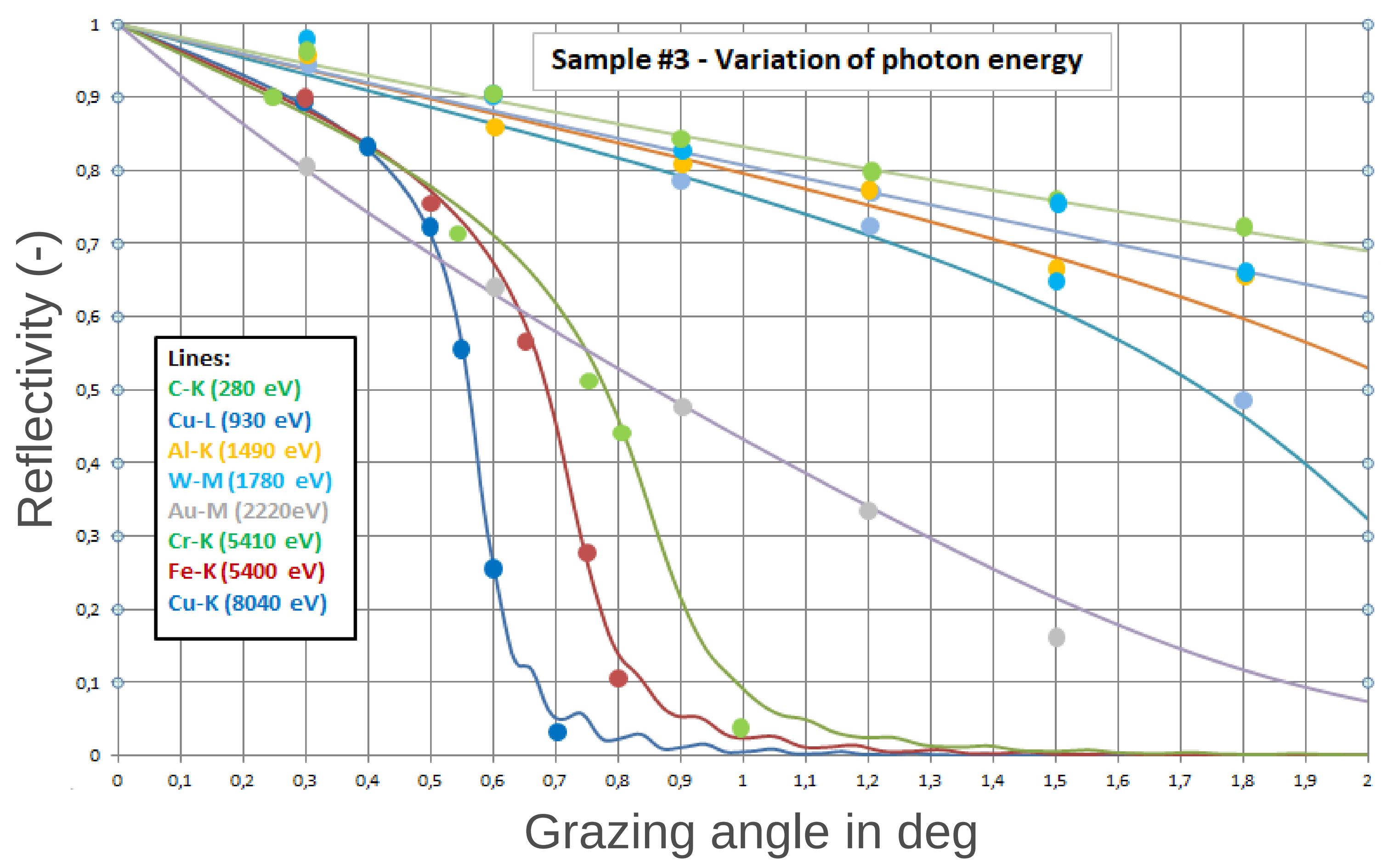
Experimental set-up for the reflectivity measurements inside the large vacuum test chamber at PANTER and an example of a picture from TROPIC detector



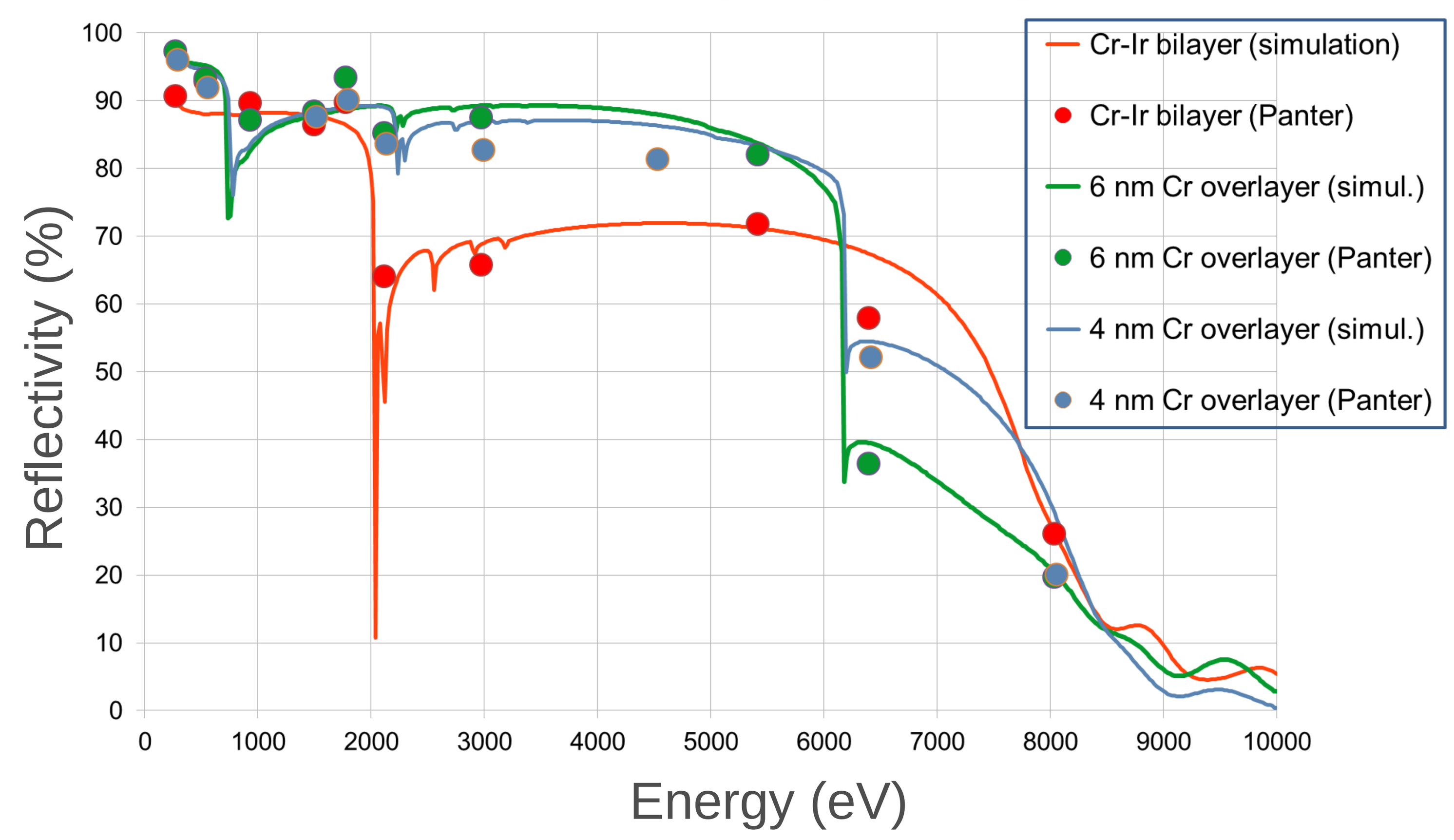


Setup for measurements was based on previous experiences from eRosita telescope mirrors testing. Not all lines were measured for all samples, the test was individually fitted according to theoretical expectations.

Results of X-ray reflectivity measurement



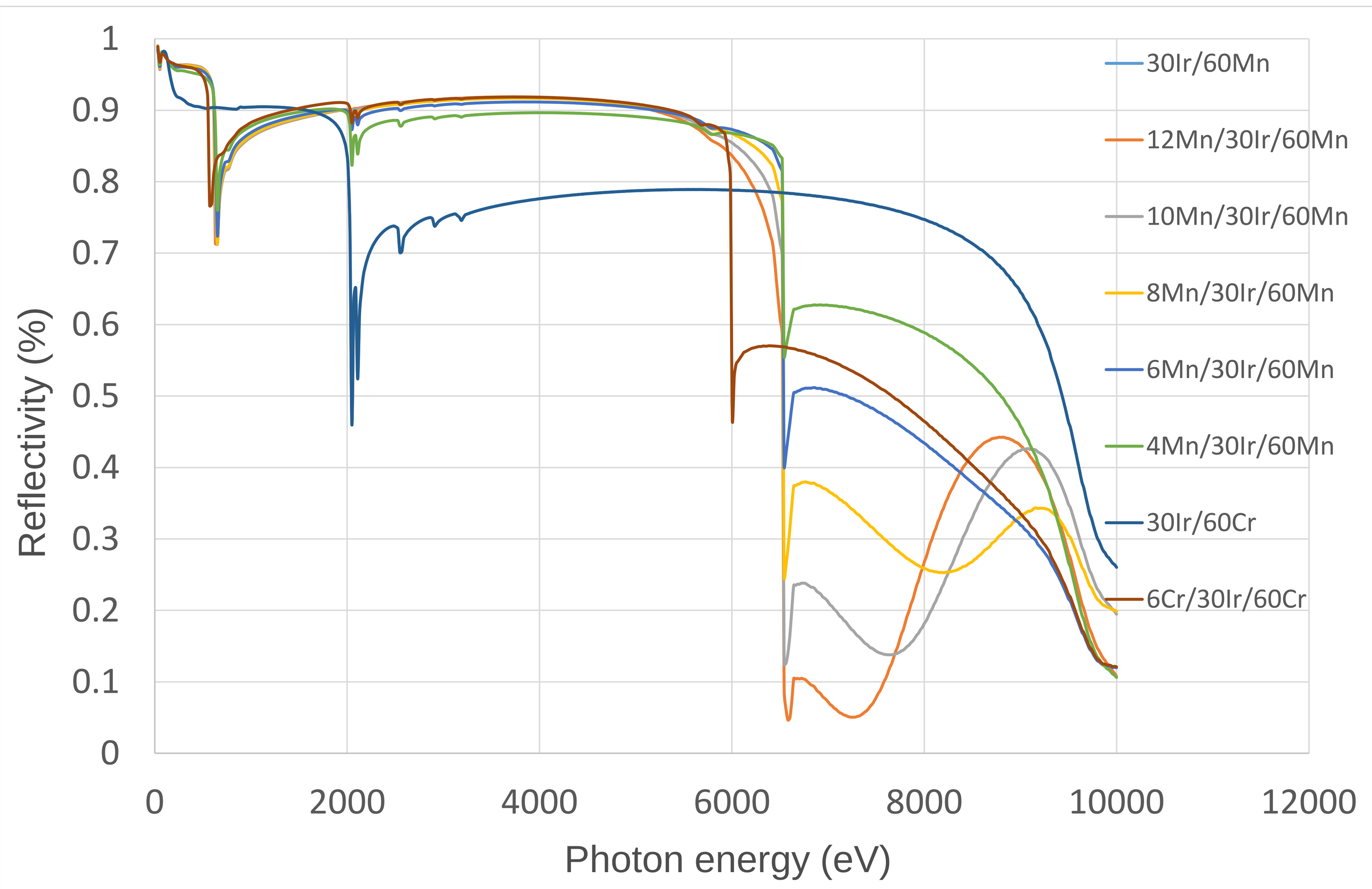
Cr-Ir-coatings: All preliminary results fit well to reflectivity simulations (30 nm Ir, 40 nm Cr, σ_{rms}=0.5 nm).



Cr-Ir-Cr tri-layer system with an overcoat of 4 nm or 6 nm Cr fills up the Iridium energy gaps around 2 keV. Panter test with error bars included.

Future progress

Not only chromium, but also other materials could be used with advantage as a carrier and overlayer material. As an example here is shown manganese, which seems to pull the effective reflectivity down at slightly higher energies than chromium. On the other hand, all other layers combination require also tests of environmental stability, without which they are not proof to be suitable for space applications. These aspects are part of our future aims.



Conclusion

Practical measurements at an X-ray facility show that Cr-Ir-Cr tri-layer systems with an overcoat of a few nanometer of Cr can increase the X-ray reflectivity with respect to Ir-Cr bi-layers at lower energies. Further evaluations are ongoing and the usage of other materials for such types of multiple layers systems is discussed.

Acknowledgement

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