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Surface analysis of strip coated materials pre- and post- 'cleaning'

Keywords
Particulate,
high sensitivity XPS

Application Note MO447(A)
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Overview

Strip coating materials are commonly used in optic applications for the removal of grease and small particulates form the surfaces of delicate materials. Typically these include mask gratings, laser optics, telescope lenses and refractors. A clear red solution consisting of a blend of polymers is applied using a small brush and is then left to set. Once set, the polymer coating is peeled away leaving a pristine surface free of particulates.

Introduction

For this study the interest concerned extent to which surface contaminants were removed and whether or not the polymer solution left and trace material on the surface. Such deposition could impact upon the optical/electronic properties of the cleaned surface. Previous XPS studies[1,2] have analysed the surfaces post application and found the surface to be depleted in carbon contamination with little subsequent deposition. These previous XPS studies were performed on old instruments where the sensitivity performance and therefore detection limit for low abundance materials is significantly lower than current instrumentation.

In this study we apply the cleaning solution to three different materials – aluminium metal foil, silicon wafer and glass microscope slide. We will discuss the change in surface contamination and therefore quantification pre and post cleaning. The strip coating used in this study is First Contact™ Polymer solution manufactured by Photonic Cleaning Technologies.

Experimental

XPS was performed using the state-of-the-art AXIS spectrometer. Survey spectra were acquired over a large energy region of 0 to 1350 eV. The co-axial charge neutraliser was used to mitigate against the loss of photoelectrons and subsequent charge build-up. Samples analysed were uncoated (virgin), coated with the solution (coated) and after removing the coating (post coat). The First Contact™ layer was applied to all surfaces in the manner described by the manufacturer and removed using the adhesive tape provided. Samples were left for >1 hour to ensure complete drying of the coating.

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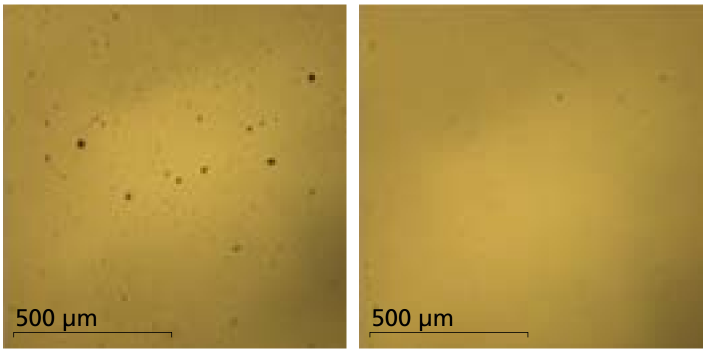
Results

After introduction into the analysis XPS analysis chamber, survey spectra were acquired for both the virgin and post-coated surfaces for the three systems (Al, Si and glass). Optical images were also acquired using the in-situ microscope (see fig.1). The optical images acquired for the pre- and post-cleaned surfaces show a significant distribution of particulates present on the virgin surface.

Figure 1: Optical microscope images of Si wafer surface pre (left) and post (right) strip coating cleaning.



The number of these particles decreases significantly post strip cleaning. Example survey spectra for the Al foil can be seen in figure 2 pre- and post-cleaning. Also included is the spectrum for the polymer coating applied but not removed. As expected for this system the surface is mostly comprised of aluminium and oxygen, formed form the oxidation of the aluminium metal. Carbon is present in its adventitious form as is a small amount of nitrogen and fluorine, most probably surface contaminants. Magnesium is present, added to improve material properties through solid solution strengthening and increases the foil's strain hardening ability. After adding the coating the survey spectrum shows a complete loss in the Al 2p and 2s signal indicating that the film coverage is 100% and that the film thickness is greater than the analysis depth of XPS. As anticipated, the elements present are C, O and N.

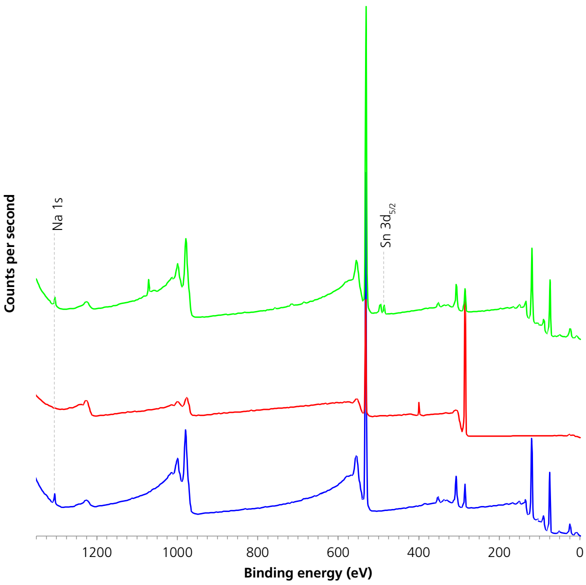


Figure 2: Comparison of survey spectra acquired for virgin (blue) coating applied (red) post coating (green) for Al foil.

After 20 minutes the film had dried and could be peeled away using the prescribed method. The surface was reanalysed and the changes in surface concentration shown in table 1. Most significant is the appearance of Na and Sn – comparison post-cleaning spectra displayed in figure 3. These elements were found on all three strip cleaned surfaces and more significantly neither of these elements were detected on the original surface of the Al foil or Si wafer.

Table 1: Surface elemental composition of Al foil, Si wafer and glass slide virgin and post coating removal (red).

Element	Al foil quant.:			
	Virgin	Post-	∆	% change
Mg	0.55	0.49	-0.06	-10.91
Na	<0.01	1.26	1.26	12600
F	0.24	0.13	-0.11	-45.83
Sn	<0.01	0.21	0.21	2100
C	11.2	12.34	1.14	10.18
O	51.57	49.97	-1.6	-3.1
Al	36.41	35.56	-0.85	-2.33
N	0.01	0.02	0.01	100

Element	Si wafer quant.:			
	Virgin	Post-	∆	% change
Na	0.04	0.79	0.75	1875
O	32.83	33.72	0.89	2.71
Si	56.33	56.07	-0.26	-0.46
C	10.79	9.32	-1.47	-13.62
Sn	<0.01	0.11	0.1	1000
O	51.57	49.97	-1.6	-3.1
Al	36.41	35.56	-0.85	-2.33
N	0.01	0.02	0.01	100

Element	Glass slide quant.:			
	Virgin	Post-	∆	% change
Mg	5.82	4.3	-1.52	-26.12
Na	5.06	3.79	-1.27	-25.1
F	2.4	2.01	-0.39	-16.25
O	50.43	53.92	3.49	6.92
C	20	18.02	-1.98	-9.9
Si	15.42	16.67	1.25	8.11
Al	0.68	1.01	0.33	48.53
Ca	0.18	0.11	-0.07	-38.89
Sn	<0.01	0.17	0.16	1600

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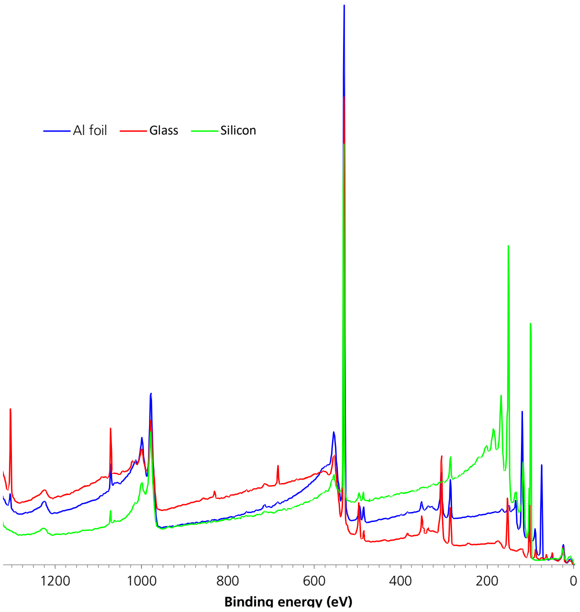

Figure 3: Comparison survey spectra for the three surfaces post-cleaning.

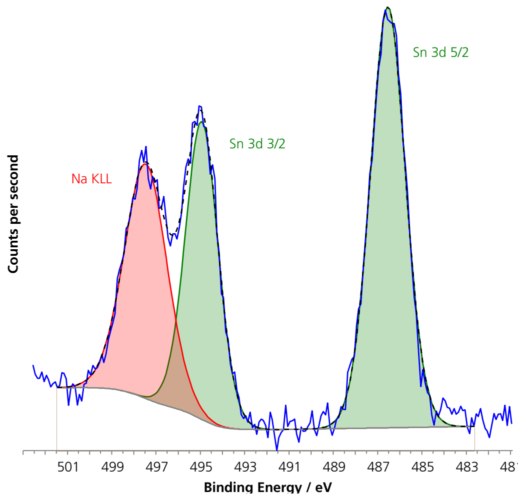

Figure 4: High resolution spectra of the Sn 3d region for Si wafer post cleaning.

To investigate further the presence of Sn, high-resolution spectrum of the Sn 3d region was acquired (fig. 4). The peak position of the primary 5/2 transition is at 486.8eV, typical for Sn^{4+} oxidation state perhaps SnO_2. Also present is the Na KLL Auger transition line Significantly there seemed to be little decrease in the overall carbon contamination found on the surface pre- and post-cleaning. This indicates that the strip process is unable to remove the adventitious carbon adsorbed by exposure to the atmosphere.

Conclusion

Strip coating material cleaning is a valid method for the removal of small mobile particulate on delicate surfaces. After application of the strip coating polymer the surface was left with residual contamination of Sn and Na. Perhaps this is the price to pay for particulate removal!

References

1. J. M. Bennett, L. Mattsson, M. P. Keane and L. Karlsson, Appl. Opt., 28, 5, 1989.
2. J. M. Bennett and D. Ronnow, Appl. Opt., 39, 16, 2000.

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