

Enhanced Space Astronomy Using Platinum Group Metals

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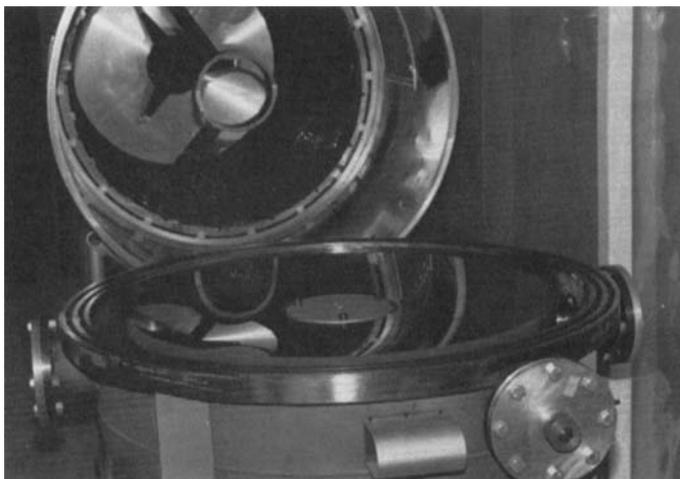
The ultraviolet region of the electromagnetic spectrum extends over the wavelength range of 10 to 400 nm, with that portion below 200 nm classified as vacuum-ultraviolet, due to its absorption by the earth's atmosphere. The advent of space flight, with its attendant ability to orbit beyond the atmosphere, has permitted astronomers to utilise vacuum-UV spectroscopy to study celestial phenomena. High resolution spectrometers that can isolate individual emission lines of atomic and molecular species have been developed, as well as highly sensitive photometers to measure the intensity and spatial distribution of the radiation.

Because of the scarcity of materials which transmit in the vacuum-UV region, these instruments use reflective optics, usually produced by coating polished substrates with high reflectance thin films. For wavelengths longer than 100 nm, aluminium has the highest intrinsic reflectance of any known film material, that is approximately 90 per cent extending into the infrared. While the natural formation of

aluminium oxide degrades this reflectance below 200 nm due to its absorption, protective overcoatings of magnesium fluoride or lithium fluoride, which prevent this oxidation, can extend the useful range down to their absorption cutoffs of 115 and 100 nm, respectively.

For the wavelength region below 100 nm, the reflectances of all known mirror coatings are depressed. In the past, platinum was considered to be the best material for this region (1) but more recent investigations have shown that films of other metals of the platinum group, including osmium and iridium, and also rhenium, are more efficient mirror coatings for parts of this region. These data have been summarised by Hass and Hunter (2). Typically, the reflectance of iridium fluctuates around 20 per cent from a wavelength of 50 nm to well above 100 nm. The reflectances of the other metals in the group are comparable.

The application of this technology to large aperture instruments has recently been accomplished with the iridium coating at the



The 0.91 m diameter telescope mirror coated with a thin film of iridium is shown mounted on the removable dome of the chamber at the Johns Hopkins University which houses the instrumentation for measuring the optical properties of the mirror surface. It is secured on the dome with a fixture which attaches at the mirror's centrally located aperture

Goddard Space Flight Center of the 0.91 m diameter telescope mirror of a spectrophotometer flown by astronomers from the Johns Hopkins University on a NASA sounding rocket (3).

Because of their high melting points, the platinum group metals cannot be evaporated by conventional resistance heating techniques used for the vacuum deposition of thin films, since they will alloy with the tungsten heater used for this purpose and cause heater failure. Instead, an electron bombardment technique has been successfully used to prepare pure films (3,4). The evaporation source used, as well as a number of other types commonly used for the deposition of thin films, produces a vapour distribution which varies as the cosine of the emission angle (5). Consequently, when the element to be coated is large compared with the vapour source, as it was in the aforementioned application, realisation of a uniform film thickness can be difficult. Fortunately, once the film thickness of iridium exceeds 10 nm, its reflectance becomes insensitive to further increases (4). Using this information, a

reflectance distribution with a coefficient of variation below 1.5 per cent was attained, despite a twofold variation in film thickness over the surface of the mirror.

While an increase in vacuum-ultraviolet reflectance from about 10 per cent for an over-coated aluminium mirror to 20 per cent or more for iridium or other metals in the platinum group may seem quite modest, it represents a significant improvement to scientists studying weak signals from distant sources with instruments using multiple reflections in the optical train.

References

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Carbide Phase Identified in Platinum

While platinum is known to have considerable solubility for carbon in the molten state, metallographic and X-ray diffraction studies reported previously by G. L. Selman, P. J. Ellison and A. S. Darling have shown that in the solid state carbon solubility is very small, the excess carbon precipitating as graphite in flake form (*Platinum Metals Rev.*, 1970, **14**, (1), 14-20). No evidence for the formation of carbide phases was found in this work, nor has it ever been reported in the literature and it is assumed that platinum does not form carbides.

However, recent transmission electron microscopy studies reported from the University of California by M. J. Whitcomb, U. Dahmen and K. H. Westmacott on platinum containing small amounts of carbon retained in supersaturation by quenching has provided direct evidence for the formation of a carbide phase on subsequent ageing (*Acta Met.*, 1983, **31**, (5), 743-747). In their studies on material aged in the temperature range 400 to 530°C, very small plate-shaped precipitates were observed to form on {001} crystallographic

planes of the platinum matrix. Electron diffraction measurements reveal the precipitates to have a body-centred-tetragonal structure with a *c/a* ratio of 3/2 and with a composition equating to Pt₂C.

The discovery of the formation of a platinum carbide phase is, perhaps, surprising although an orthorhombic carbide has been reported in nickel, which is in the same group in the periodic table as platinum and which had also been thought to form only graphite structures with carbon. The stability of the platinum carbide phase is attributed to the formation of stable octets of valency electrons. The 50 per cent volume difference between Pt₂C and the platinum matrix suggests that Pt₂C will be more difficult to nucleate than similar metastable eta carbides in ferrous alloys, which also precipitate as platelets on {001} matrix planes and which are transition phases in a sequence ending in graphite formation. The authors believe that Pt₂C is also an intermediate phase that provides a more energetically-favourable path to graphite formation.

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