Low Reflectance Coatings

PLATINUM BLACK FOR INFRARED TECHNOLOGY

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In recent years, the infrared region of the spectrum has acquired a new importance due to rapidly developing technology which has divers applications, many of which are concerned with energy conservation, space, or the military. Coatings with a very low reflectance over the thermal infrared region, that is which absorb nearly all the incident radiation, are valuable for the components and screens which make up the optical systems used in sensing, measuring or imaging infrared radiation. This is especially true of the actual detectors of radiation used, many of which are thermal detectors which need a coating of uniformly high absorptance over the infrared spectrum.

The National Physical Laboratory (NPL) has recently set up new measuring capabilities to cover the infrared region, and an investigation of coatings for detectors was carried out as part of this endeavour (1). The measuring technique involved the use of a novel NPL hemispherical reflectometer/transmissometer(2,3,4), the principle of which is illustrated in Figure 1. This facility allows the complete set of radiometric properties of a surface to be evaluated over the whole thermal infrared spectrum, from 2.5 to 55 micrometres. Another aspect of the investigation was the angular scattering characteristics, which were measured at Sira Ltd. (1) and which complemented and confirmed the conclusions of the spectral reflectance measurements at NPL.

The coating for a detector needs to be fully absorbing yet thin enough not to add significantly to the thermal heat capacity, and at the same time it needs as high a thermal conductivity and thermal diffusivity as possible. This combination of properties suggests finely divided metals as the best solution, but not as powder adhering by means of a bonding agent: the metal must be spongy or dendritic and directly "grown" on the metal substrate.

Chemical, electrochemical, or sputtering techniques are preferred, and examples of a number of finely divided metal black coatings were prepared and investigated. Preparations of nickel black, aluminium black and platinum black were made by various techniques (1), but gold black was excluded because it had been extensively investigated elsewhere (5) and also was known to be difficult to prepare reproducibly. A characteristic of all such coatings is that beyond a certain wavelength, determined by the thickness and metal, the coating ceases to be opaque. The best known of the special purpose black paints for radiometric applications, Nextel 101–C10 manufactured by the Minnesota Mining and Manufacturing Company, was also included to give a standard of performance for comparison purposes.

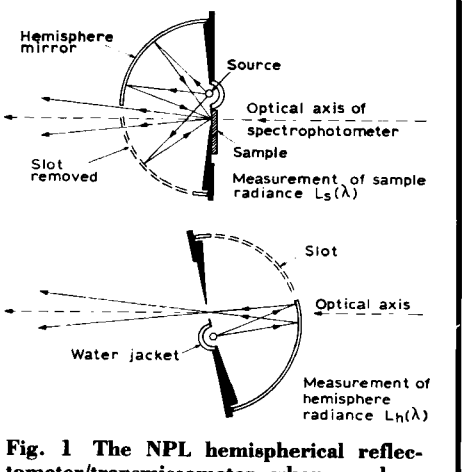

Fig. 1 The NPL hemispherical reflectometer/transmissometer when used as reflectometer. $L_a(\lambda)/L_h(\lambda)$ gives the diffuse reflectance of the sample

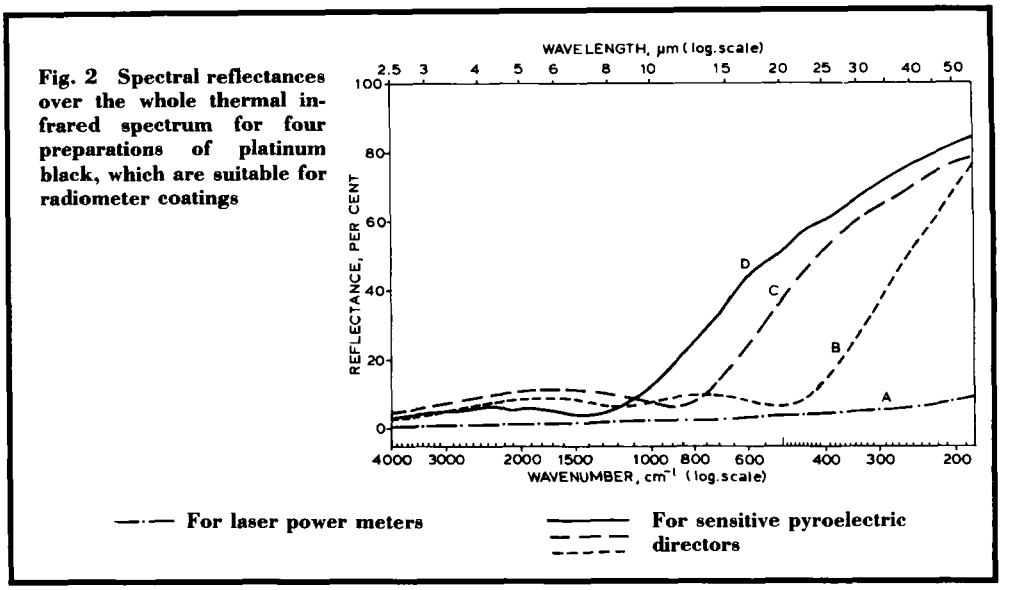

Fig. 2 Spectral reflectances over the whole thermal infrared spectrum for four preparations of platinum black, which are suitable for radiometer coatings

Results showed that platinum black had the best properties of the materials investigated. Figure 2 shows the spectral reflectance data over the whole thermal infrared spectrum for four preparations of platinum black. The substrates were of polished copper, chosen because of its high reflectance to reveal any deficiencies of opacity. Curve A shows excellently low and non-selective values for a coating of 6.8 mg/cm^2, which is less than would be required for any known black paint to achieve comparable performance. The other curves shown in Figure 2 are preparations of only around 0.6 mg/cm^2, chosen to be as thin as is compatible with achieving low reflectance up to around 10 micrometres. This is the requirement for high-performance detectors sensing through the atmospheric transmission band from 8 to 12 micrometres; the water and carbon dioxide in the atmosphere cut down atmospheric transmission severely in most other parts of the infrared spectrum. Curves B and C are the results of attempts to prepare identical coatings, and indicate that reproducibility is a problem for platinum black when grown on a substrate.

Organisations with special expertise in preparing these platinum black surfaces are: AWRE at Aldermaston, Plessey Research (Caswell) Ltd. and Thorn-EMI Ltd. Applications other than detector coatings are: black reference plates and targets for radiometric calibration of infrared systems; coatings on reference black body cavities (specially critical when the cavity has to be rather flattened in shape, as with some satellite or spacecraft applications); non-reflecting coatings around the edges of diffraction gratings, lenses and mirrors, and their supports; and small heat exchangers or external skin radiators in aerospace applications. In all these cases the cost of platinum is not a problem, but for other larger-scale applications, like commercial solar heat exchangers, other coatings would be more cost-effective.

References

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