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The determination of reflectivity of a metal film at submillimetre wavelengths using an electrical substitution technique and a dedicated microprocessor system

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Abstract. A dedicated microprocessor system is used to obtain the reflectivity of a thin metal film at submillimetre wavelengths. Using a pyro-electric element as a null detector and by automatically maintaining a null output from the detector, reflectivity values are obtained with greater accuracy than before.

The conducting surface to be investigated is vacuum deposited on the surface of a lead zirconium titanate (PZT) pyro-electric element. A laser beam is allowed to be incident on the film after being chopped at a low frequency. Non-reflected radiation Joule heats the thin film and the detector element responds to time variations in temperature. Good thermal contact between detector element and substrate allows detected power to be assumed equal to absorbed power in the film. With highly reflective surfaces the power absorbed (P_a) is much smaller than the incident power (P_i), so the reflectivity is given by [1]

$$R = (1 - P_a/P_i) \times 100\%$$

A small low-frequency heating current may be passed through the film and suitable phasing between this input and the laser heating input allows the pyro-electric element to be used as a null detector. Electrical substitution and null detection techniques have been used previously only with 'black' receiving elements [2, 3]. The method described in this paper allows small changes in power levels of the order of a microwatt to be detected in the form of non-reflected radiation power even though the film is highly reflective.

A simplified block diagram of the circuit used is shown in figure 1. The dedicated microprocessor system uses the chopper reference signal for timing and phase control. The sampled null amplifier output is used to generate a heating signal fed in in anti-phase mode to the chopped laser input to the film. This heating signal is used to determine the magnitude of the absorbed power (P_a) and hence reflectivity R can be calculated. The incident radiation power is determined independently using a calibrated disc thermopile [4, 5], the absolute accuracy of which has been obtained over the electromagnetic spectrum of interest by the National Physical Laboratory Calibration Service.

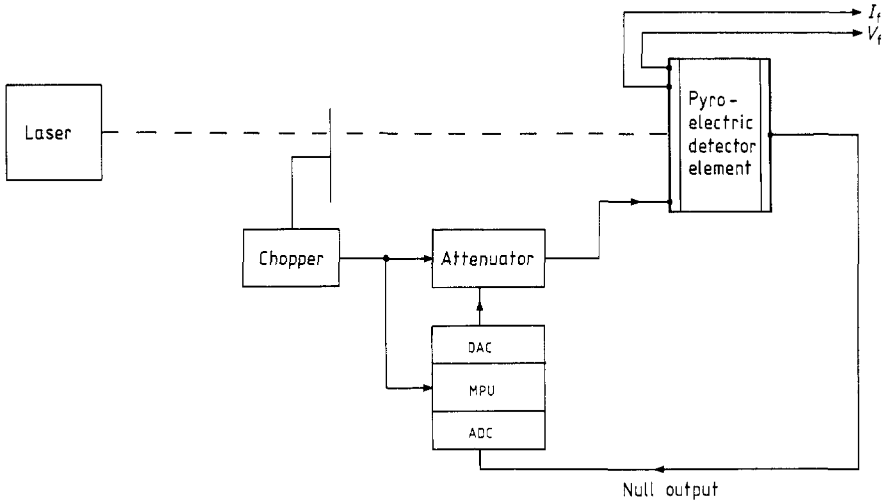

Figure 1. The experimental arrangement for measurement of reflectivity of a conducting film. V_f is the voltage across the film and I_f is the current through the film allowing absorbed power to be determined as the product of V_f and I_f.

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