Ruthenium Resistor Glazes for Thick Film Circuits

It is only two years ago that, during a conference organised by the Institution of Electronic and Radio Engineers and the Institution of Electrical Engineers on the technology of "thin film" elements and circuits, the first significant references were made to "thick films" in the same context of microelectronics.

The preparation of metal films, notably of silver, gold or platinum, by a process of screen printing a metallic ink on to a ceramic substrate and then firing, has been known and practised for many years in the production of discrete components such as capacitors, but the development of this technique for micro-circuits has been both recent and rapid, stimulated by the relative ease and low cost with which such circuits can be produced. The very considerable interest and importance now attaching to this field were clearly demonstrated during a conference on "Thick Film Technology" held at Imperial College, London, in April, again organised by the IERE and the IEE, and attended by over four hundred engineers from twelve countries.

Among the papers presented during this meeting was one by G. S. Iles of Johnson Matthey Research Laboratories on "Ruthenium Resistor Glazes for Thick Film Circuits". The development of a new type of glaze resistor preparation based on ruthenium dioxide was initially described in this journal some nine months ago (*Platinum Metals Rev.*, 1967, **11**, 126). The objective was to devise an ink based on a chemically inert system that would depend on the firing stage to fulfil two simple functions, namely the burning out of the organic matter in the vehicle and the sintering of the metal oxide/glaze particles. The further requirements that had to be met were the availability of a wide range of resistance values, low temperature coefficients and the most economical use of ruthenium. These characteristics have all been achieved in the range of preparations now available, and smooth, well defined films may be obtained by screen printing through normal mesh sizes. The prints are fired in the temperature range 600° to 800°C to give films of the order of 0.0005 to 0.001 inch in thickness, the relatively low temperature of 600°C allowing the use of cheaper substrates than has hitherto been possible with thick film resistor pastes.

Since the publication of the first paper on these new glaze preparations the range of resistance values has been extended, and resistances from 5 to 100,000 ohms/sq/mil can now be provided. Inks with intermediate values, instead of being mixed by the user, are produced during manufacture by the blending in special equipment of a limited number of master batches with established values. This ensures that the inks are homogeneous and possess the required electrical properties.

Temperature coefficients in the range $\pm 100 \times 10^{-6}/°C$ can be expected with sheet resistivities from 50 to 5000 ohms/sq/mil, with an improvement to within $\pm 50 \times 10^{-6}/°C$ where particular attention is paid to the precision of printing followed by a firing schedule that is controlled and reproducible. At the higher end of the resistance range, from 5000 to 100,000 ohms/sq/mil, temperature coefficients from -50 to $-200 \times 10^{-6}/°C$ may be expected, but the technique of preparation of this family of inks makes it possible to adjust temperature coefficients to fulfil a particular requirement.

Measurements carried out so far indicate that resistors produced from these ruthenium oxide glazes possess high stability and give acceptably low noise levels.