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## Maintaining Accurate Temperature Control

### THE CARE OF PLATINUM THERMOCOUPLES

The use of carefully prepared thermocouples, the exercise of care and attention to details of installation, and the maintenance of calibration by frequent checking, all demand infinite patience, but are essential to the assurance of accurate and consistent furnace temperature control. That this is of primary importance in the semiconductor industry is emphasised in a paper by Ivan O. Nielson of Fairchild Semiconductor (*Solid State Technology*, 1968, **11**, (10), 29). A typical example of the diffusion process for introducing controlled impurities into silicon or germanium wafers requires a furnace operating at  $1020^{\circ}\text{C} \pm 2^{\circ}$ . Wider temperature variation produces variance in the beta characteristics of the devices.

The thermocouples used for control are platinum: 13 per cent rhodium-platinum in the form of wire 0.014 inch diameter to give quick response. The junction, formed by a butt weld, is little larger than the wire diameter. Before use each thermocouple is electrically annealed at about  $1350^{\circ}\text{C}$  for one hour to remove work hardness and volatile surface impurities. The thermocouple is insulated with double-bore refractory tubing and protected in the furnace with a quartz sheath. Leads are terminated with a crimp spade lug to ensure good mechanical connections.

Working-standard thermocouples are calibrated at known points of reference, and are used to calibrate the furnace thermocouples

by comparison, using a heat-sink block in the calibration furnace and connecting the couples so as to give a difference reading. Working-standards are calibrated every four weeks and are used only for one week at a time.

Owing to the quicker deterioration of thermocouple e.m.f. at higher temperatures, the frequency of calibration varies according to the temperature being measured, ranging from every two weeks to every six months. Each diffusion furnace has a thermocouple that is used only in that furnace.

The temperature profile of each furnace is carefully checked before use. A period of 10 to 15 minutes is allowed to equalise the temperature at each point and for the system to become thermally stable. The furnaces are wound in three zones and thermocouple controls are so arranged that variations in the centre zone control the end zones. A diffusion furnace is only as good as the instrumentation system which controls it.

Advancements in technology, not only in the semiconductor field, demand higher productivity, and the accurate control of temperature is a means to this end. Particular care must, therefore, be given to frequent calibration of working thermocouples and measuring instruments, to constant checking of all connections in the system, and to allowing sufficient time for thermal sensing devices to reach stability.

H. E. B.