Electronics Research Laboratory
University of California
Berkeley, California

A RESISTANCE HEATER FOR SEMICONDUCTOR WAFER PROCESSING

by

Ruth Talcott

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Heating wafers of silicon and germanium at carefully controlled temperatures and atmospheres is basic to many processes in the fabrication and study of semiconductor devices. Diffusion, oxidation, alloying and epitaxial crystal growth are some examples.

Usually, heavily insulated tube furnaces employing radiation heaters are used for these processes, except in the epitaxial growth processes for which rf or induction heating is frequently used. The heating equipment is large and expensive.

A resistance heater, as described below using a low voltage, high current ac power supply, offers some advantages over present techniques. At least it offers a convenient method of heating wafers for small laboratories which do not have more elaborate equipment available. The heater is of particular interest for the epitaxial growth of silicon.

The heat source is a piece of pure graphite cut into a U or W shape with split copper rods inserted into holes at the free ends. The cross-sectional area is greatly increased in the region of the contact between the copper and graphite so that the cooling by radiation from the graphite is enough to keep the contact region well below the melting point of copper.

The graphite heater element is made to fit inside square quartz tubing* and a quartz support can be used to keep the graphite in close contact with the top of the square tubing. A gas-tight seal is made around the copper leads using a block of any soft machinable insulating

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*Quartz parts were fabricated by Berkeley Glasslab, 1717 Fifth St., Berkeley 10, California.

material such as Micalex or boron nitride, with Gyptal as the sealant. This block also serves to support and space the leads and prevents undue strain on the rather fragile heater. Two small copper tubes through the support block should be provided for flushing the heater region with argon. These can be sealed after moisture and oxygen are driven off in the first heating cycle.

The top of the square quartz heater sleeve is roughened, or grooved if possible, and the wafers are placed on this surface where they receive heat both by radiation and conduction through the quartz. The grooving counteracts the tendency of the wafers to slide off the quartz due to heating of the trapped air film under them.

The whole heater assembly should be supported at one end so that wafers can be loaded and unloaded by merely pulling away the cylindrical outer jacket. Stainless-steel wool has been used for a resilient cushion between the aluminum block support and the square quartz tubing. A circular disc flange with vent and thermocouple holes is sealed on to the square heater sleeve and this base flange is in turn clamped to a flat ground rim on the cylindrical outer jacket in order to form a gas-tight connection to the outer jacket. Gases are introduced either through one of the tubulations on the base flange or through a tubulation at the end of the outer jacket.

The heater owes its efficiency to the use of reflectors (not shown in the figures) around the outer jacket. When reflectors are used it is necessary to air cool the outer jacket, especially if plastic or rubber tubing is used for gas connections. This has not been very difficult.

Temperature uniformity along the heater for a distance of five inches was within 5° C at 1100° C, measured with a Leeds and Northrup optical pyrometer. Polished silicon wafers oxidized in air to a thickness of 1000 Å were uniform in color over their surface. This would indicate a uniformity in thickness of better than $\pm$ 50 Å.

Power requirements are about 20 v., 185 Amps., for a wafer temperature of 1100° C.

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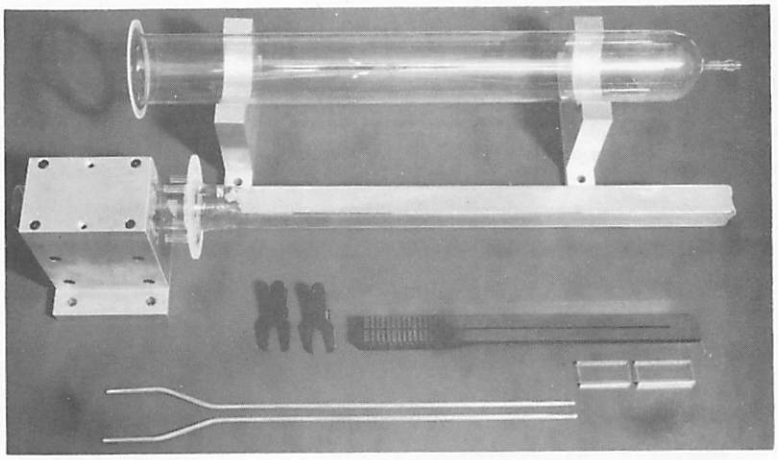

Fig. 1. Parts for wafer heater—unassembled.

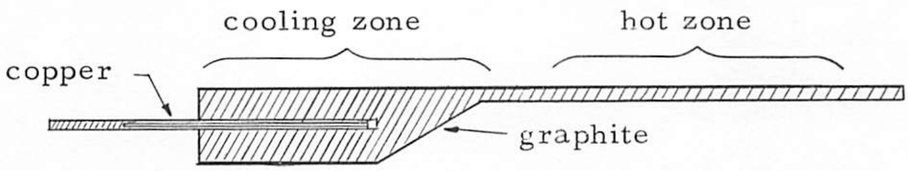

Fig. 2. Cross section through one lead connection.

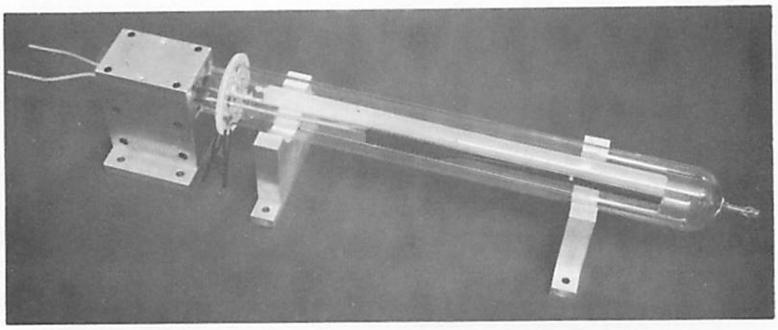

Fig. 3. Wafer heater—assembled.

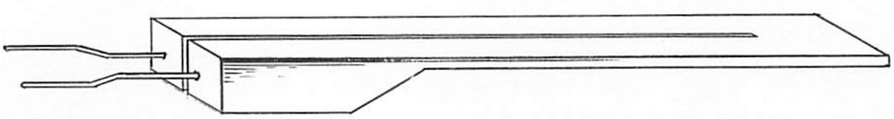

Fig. 4. Perspective of graphite heater and copper leads.