

TOWARDS THE INTELLIGENT KITCHEN

by:

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INTRODUCTION

In recent generations of household appliances, there has been a noticeable increase in the use of electronic circuits. The use of such control circuits has led to increased appliance functionality, a reduction in the use of resources, and effective and lasting savings in household costs. Moreover, these intelligent systems are helping to improve further the convenience and efficiency of domestic work. Exact temperature measurements combined with carefully designed electronic controllers extend the lifetime of both an appliance and its components. The use of this type of technology is becoming increasingly evident not only in many traditional technological and engineering sectors but also in a growing number of areas in everyday life. For precise temperature measurement, the electronic control circuit requires the signal from a suitably accurate temperature sensor. The versatility of platinum temperature sensors based on thin-film technology make them ideal for a wide variety of domestic applications.

PLATINUM TEMPERATURE SENSORS

Today's platinum temperature sensors comprise structured and encapsulated platinum thin-film elements. These are created under clean room conditions using techniques from the semiconductor industry such as sputtering, vapour deposition, photolithographic structuring and laser trimming.

This is the stage at which the reproducibility of the method is tested with a view to subsequent large-scale production. The platinum metal structure is deposited on a aluminium oxide ceramic substrate and then covered with a thin layer of glass. The bond pads for creating electrical connections to the meander shaped platinum structure are also sealed using a special glass-ceramic paste (Fig. 1).

THE VARIETY OF FORMS FOR PLATINUM TEMPERATURE SENSORS

Platinum thin-film sensors are available in a broad variety of forms. Depending on the proposed application, the sensor may be unhoused, encapsulated in ceramic, configured as a surface mounted device (SMD) or located within a plastic housing with rigid pins. An overview of the variety of different forms currently available is presented below (Fig. 2).

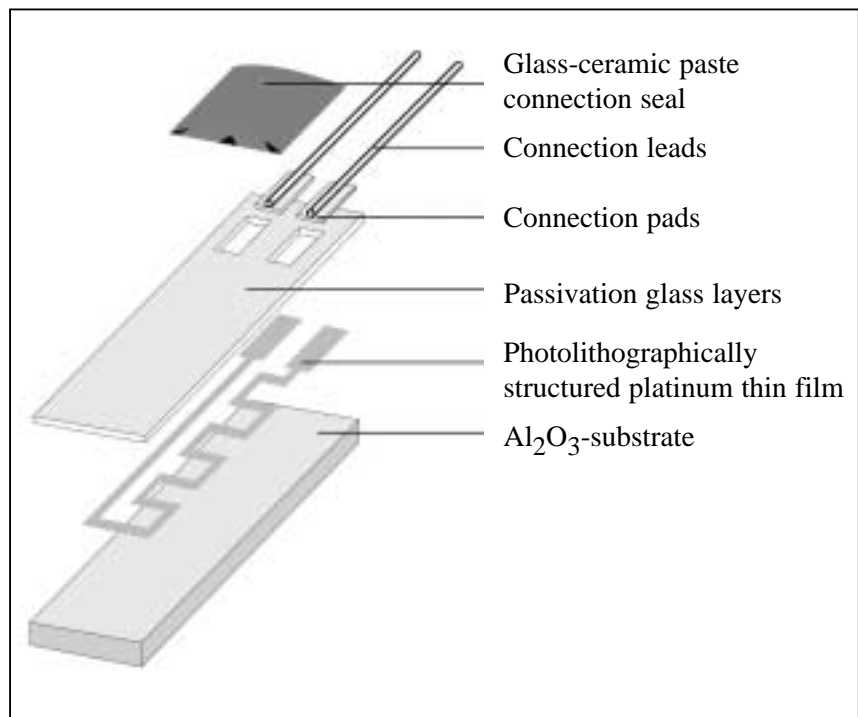


Figure: 1

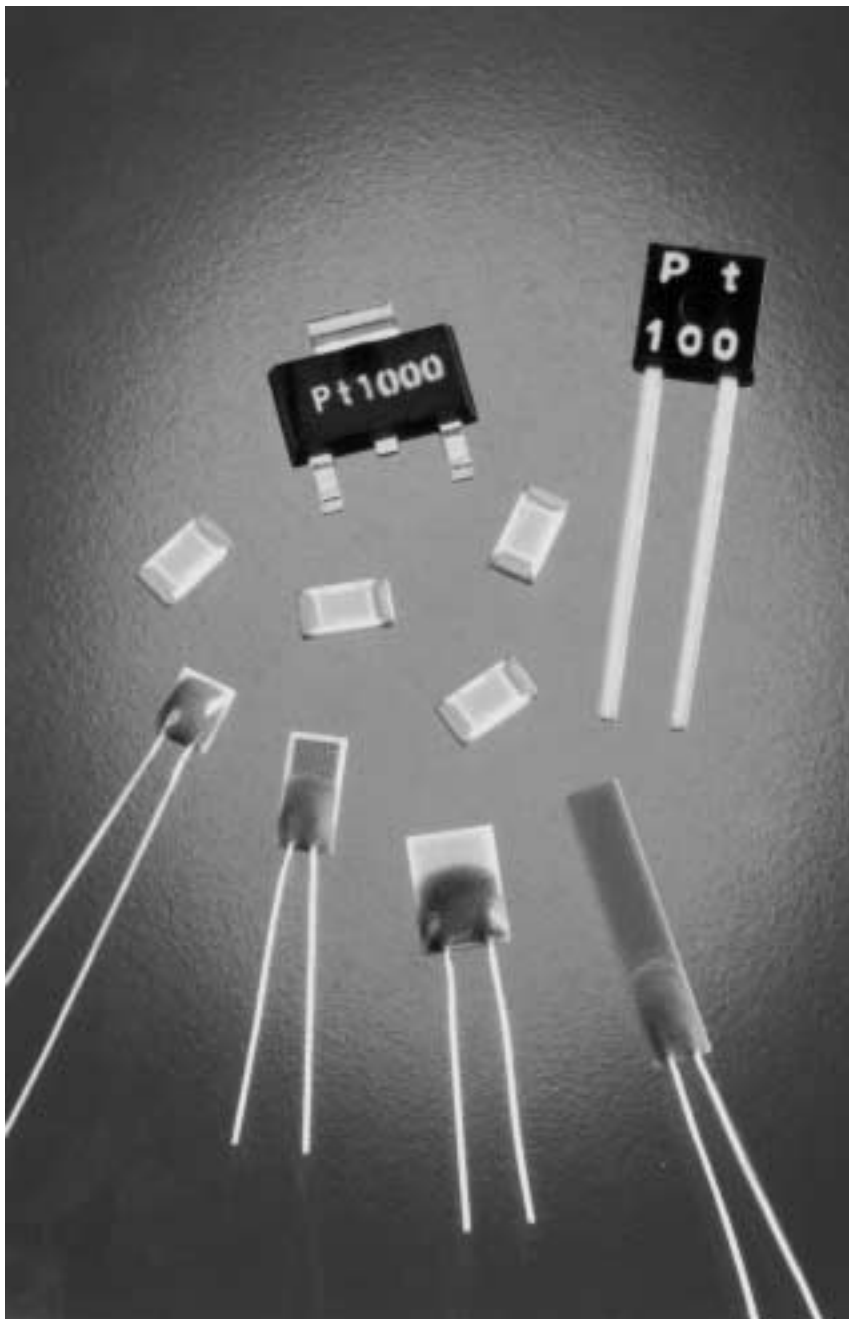


Figure: 2

TEMPERATURE DEPENDENT CHANGES IN ELECTRICAL RESISTANCE

Platinum sensors exploit the fact the electrical resistance of platinum metal is temperature dependent. This behaviour can be described by a polynomial of the form

$$R_t = R_0(1 + at + bt^2). \quad (I)$$

Here R_0 is the resistance at 0°C , and a and b are coefficients whose values are specified in internationally agreed standards covering platinum temperature sen-

sors, for example DIN EN 60751. The coefficient b is so small that for most applications one can assume a linear relation between R_t and the temperature t .

For each type of sensor there are specified tolerance ratings which dictate the measurement precision to be expected when that type of sensor is used. Platinum temperature sensors have a positive temperature coefficient which is defined as:

$$TC = (R_{100} - R_0) / (100 * R_0) \quad (II)$$

The temperature coefficient TC is the gradient of the linear approximation

of the polynomial I between 0°C and 100°C . In the DIN EN 60751 standard, the temperature coefficient for platinum temperature sensors is specified as $0.003850/^\circ\text{C}$.

ADVANTAGES OF PLATINUM TEMPERATURE SENSORS

The economic large-scale production of platinum temperature sensors is now possible due to the application of modern manufacturing techniques based on thin-film technology. This development has led to price levels which were previously the exclusive domain of NTC elements. By modifying individual process stages, a broad range of variants differing in structure, resistance values and geometry can be realized. Besides classical temperature sensing applications, platinum combination sensors also enable other physical quantities to be monitored. Such combination sensors are used, for example, as air mass meters in car engines. Furthermore, the high level of automation in the production process permits extremely precise miniature sensors to be manufactured which are capable of meeting the exacting demands required by physical, biochemical and medical applications. By fine tuning the sensors properties to meet these requirements, even mass markets can be supplied with these advanced technological sensor devices.

HIGH TECH IN THE HOME

Given this situation, it is not surprising that, over the last few years, products based on platinum thin film technology have been finding increasing use in the domestic environment. With the growing use of electronic control systems in the new generation of domestic appliances, platinum temperature sensors have been finding increasingly widespread use in ovens where they have replaced electromechanical regulators such as capillary tube and solid expansion thermometers and NTC thermistors. Typical sensor applications in the food preparation sector are shown in Fig. 3.

Even conventional hotplates can be fitted with a continuously variable temperature control thanks to platinum thin-film sensors. The encapsulated platinum sensor is positioned so that it is in contact with the cast iron plate from below and thus able to register the temperature of the hotplate. Normally the power supplied to the plate is regulated by a stage switch. The increased control sensitivity is made

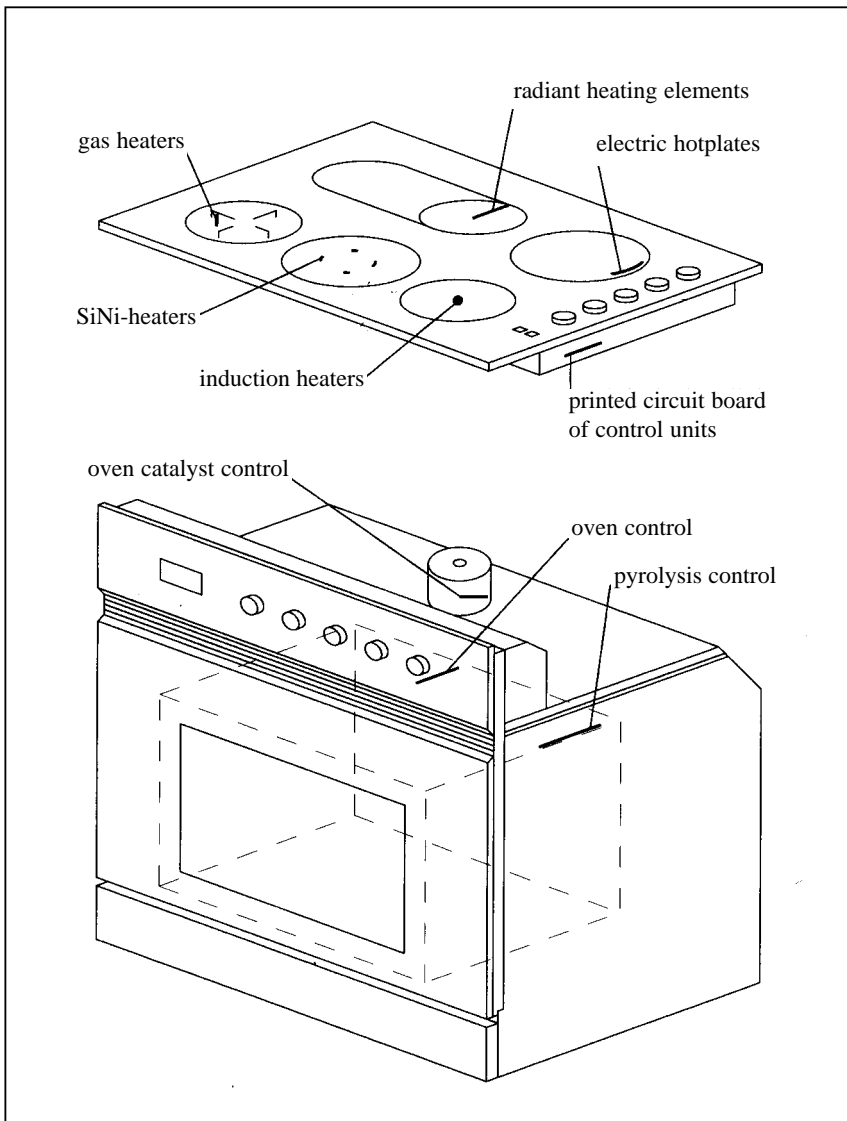


Figure 3

ossible by incorporating electronic circuitry capable of interpreting and acting upon the sensor signals.

imilar technology is also being used in induction hotplates and radiant heating elements and in the silicon nitride hotplates currently under development and which are characterized by the excellent heat transfer between the heat source, the sensor and the saucepan. Gas hotplates could also be provided with the latest in domestic temperature sensing technology by fitting them with electric temperature control circuitry.

Intelligent process control based on platinum temperature sensors and tailored electronics provides an effective method of improving both kitchen safety and the user friendliness of kitchen appliances, and also contributes to reducing energy consumption.

The growth in the use of platinum sensor technology is to be found, above all, in ovens. The sensors are used to fulfil two main functions:

The sensors measure the temperature in the oven during the baking process. The precise temperature measurement achievable contributes effectively to reducing hunting oscillations. The electronic control systems now in use have also made it possible to store different heating profiles which the oven can use to react intelligently to the different types of food being baked. By exploiting this type of technology there is no longer a need to cook by trial and error nor to have to adapt the baking process to the quirks and peculiarities of a particular oven.

The use of catalytic converters in modern domestic ovens means that

odours in the kitchen arising from baking and roasting are now a thing of the past. The catalytic converters are fitted into the oven's venting shaft and convert unpleasant smelling substances into CO, CO₂ or other non-odorous gases. To provide the best possible control of the catalytic odour eliminator, platinum temperature sensors are employed to ensure that the catalyst is working in its optimum operating range, typically 500-550°C. An analogous function is fulfilled by sensors that are used to control the pyrolytic cleaning process. This involves heating the entire oven to a temperature of around 550°C, a temperature high enough to make oven cleaning with the usual chemical cleaners superfluous. The high temperature achieved, pyrolyses any organic compounds present and the ash residues can then be easily removed from the oven by brushing. Platinum high temperature sensors provide a reliable means of monitoring and regulating the temperature and thus safeguard the safe and complete pyrolysis of food deposits in the oven.

Economic considerations also make platinum temperature sensors attractive to users, enabling high temperatures to be measured at an affordable system price. In contrast to conventional thermoelements, platinum sensors do not demand complicated analysis electronics and are insensitive to electromagnetic field influences.

EXAMPLES OF APPLICATIONS

Figure 4 presents a number of platinum sensors currently being used in kitchen appliances. The probe with the flange and the long stainless steel housing was developed for use in ovens. Also available are models equipped with high-voltage insulation which can be built in if demanded by the control electronics. The shorter sensor with the tapered form is a customized high temperature probe which was built to order for a client. On the right of Fig. 4 is a sensor designed for measuring surface temperatures. The sensor, which is integrated into a plastic housing, is easily mounted via the bore hole. Besides these special probe geometries, a universal sensor in a ceramic housing is also available. Situated in the centre of the picture is an SMD component on a long ceramic plate that is used for temperature measurements up to 750°C. In addition to the designs shown, Heraeus Sensor-Nite is able to develop and manufacture sensor geometries and housings that are specially tailored to meet



Figure: 4

FUTURE PROSPECTS / OUTLOOK

In principle platinum sensors can be used for applications in the temperature range -200°C to $+1000^{\circ}\text{C}$. In the kitchen, temperatures typically ranging between 200 and 600°C are measured. The ability to accurately measure lower temperatures, opens the possibility of using platinum sensors in fridges, freezers, washing machines and tumble dryers. Given these prospects, it is clear that the end of the road leading to the intelligent kitchen and household has not yet been reached.

Supported by the knowledge and experience at Heraeus, the precious metals and technology enterprise and one of Germany's fifty largest companies, Heraeus Sensor-Nite continues to be very active in the field of sensor technology. For many years Heraeus Sensor-Nite has been successfully involved in the development, application and serial production of platinum temperature sensors. In all its activities, Heraeus Sensor-Nite combines the experience of the Heraeus company with today's cutting edge technology. This fusion of traditional know-how with modern methods of production and analysis has

made Heraeus Sensor-Nite one of the leading high technology companies serving the environment:

NEW INNOVATIVE TECHNOLOGIES FOR THE ENVIRONMENT - NITE.

In addition to developing products to serve the domestic appliance market, Heraeus Sensor-Nite is also active in the automotive sector, and in the fields of calorimetry, electronics and medicine. The goal that Sensor-Nite has set itself for both its present and future activities is to increase process safety whilst reducing depletion of resources.

Matthias Muziol was born in Offenbach/Main, Germany in 1965. He studied mechanical engineering at Darmstadt Technical University. After graduating he took up a position as a design engineer with Heraeus Sensor GmbH. Since 1997 he has been working in the development department at Heraeus Sensor-Nite.