

# Warmth Quantification

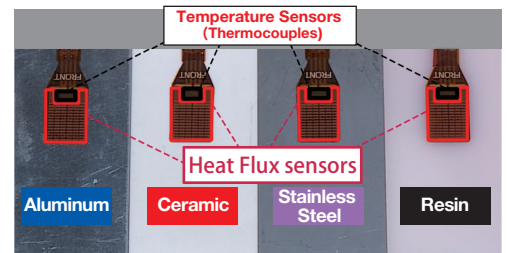
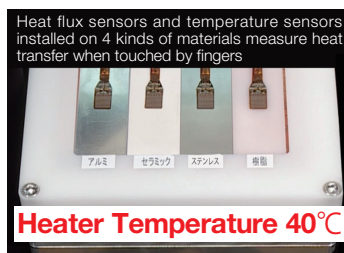
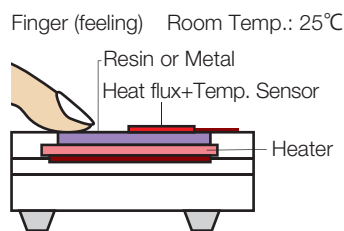
## Goal

The heat is transferred from the heater to the human body through the plate material. Depending on the plate material between the heater and the human finger, the feeling of warmth differs. Through the capture of this warming sensation by the heat flux measurement, a quantitative expression can be made.

## Measurement Method

At a room temperature of 25°C, 4 different plate materials (Aluminum, Ceramic, Stainless Steel, Resin) are placed on top of a heater set at 40°C. On each of them a heat flux sensor and thermocouples detect the heat flux and temperature. In addition, in order to perform an evaluation, the feeling of warmth is compared by touching each of the materials with a finger.

Heat flux measurement of plate material on heater & evaluation of feeling of warmth in the finger



## Results

In order to evaluate the feeling of warmth through the finger on the material plate above the heater, four kinds of material plates (aluminum, ceramic, stainless steel, resin) were used. The warmth feeling evaluation after touching is as below:

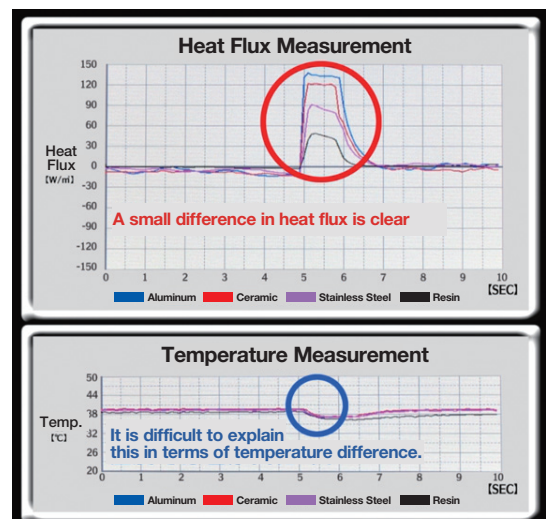
Warmth = Aluminum > Ceramic > Stainless Steel > Resin

In addition, the heat flux result measured by each of the four heat flux sensors is then as follows: Aluminum 135 W/m<sup>2</sup>, Ceramic 120 W/m<sup>2</sup>, Stainless Steel 90 W/m<sup>2</sup>, Resin 45 W/m<sup>2</sup>, with a ranking as below:

Heat flux = Aluminum > Ceramic > Stainless Steel > Resin, which is the same as the warmth feeling ranking mentioned above.

On the other hand, if the temperatures measured at the same time on each of the materials are considered, all of them were around 37°C with no difference being spotted.

Therefore, from these results we can conclude that we could quantify the feeling of warmth through the correlation with the heat flux sensor.



## Considerations

When the plate is touched, a feeling of warmth transmitted from the heater to the human body (finger) through the plate material. At this moment, the heat is taken away from the blood flow, thus giving birth to the feeling of warmth. In this study, we compared the resin and metal, the two materials with the biggest thermal conductivity (TC) difference. The TC of the resin is 0.25W/m<sup>2</sup>K, whereas that of the metal is 16W/m<sup>2</sup>K. Therefore, as this difference is very big, when touched by the human finger, the metal feels warmer. This is clearly shown by the large heat flux result through the heat flux sensor. From this result, it is clearly possible to quantitatively indicate the sensation of warmth, something that could only be done through the human senses until now. Moreover, by quantifying the level of warmth that feels comfortable to the human body through heat flux amount, we think we might be able to see the human comfort and contribute to its improvement.

## DENSO CORPORATION

1-1, Showa-cho, Kariya, Aichi 448-8661, Japan  
Sensor & Semiconductor Business Unit Sensor Business Development

**Inquiry** Heat flux sensor  
Mail: Z18045\_ENERGYEYE@denso.co.jp

For more details please check our website  
▶▶▶ <https://energyeye.com/en>

