Effects of Relative Humidity on Thermistor Mount Measurements

Wenze Yuan, Xiaohai Cui, Yong Li, and Chao Ma
National Institute of Metrology, Beijing, China, e-mail: yuanwz@nim.ac.cn, cuixh@nim.ac.cn

***Abstract*—Thermistor mounts are served as transfer standards which are calibrated in microcalorimeter. A correlation between the effective efficiency of thermistor mount and the relative humidity of the laboratory has been observed. The difference of effective efficiency measurement in 20% and 50% humidity level can be about 9 times the *k*=1 uncertainty. The effects of humidity on thermistor mounts can result in the changes of effective efficiency. While the humidity impacts on other microwave device in microcalorimeter is not the main reason of these changes.**

I. INTRODUCTION

Microcalorimeters serve as millimeter-wave power primary standards in many national metrology institutes(NMIs). The effective efficiency of transfer standards which are usually thermistor mounts is determined by microcalorimeter measurements[1]. The thermistor mount calibrated in calorimeter is the most accurate and stable transfer standard than other instruments at present. National Institute of Metrology(NIM) of China also established microcalorimeter systems to serve as primary national standards of microwave and millimeter-wave power of China. With the microcalorimeter method, the effective efficiency of a thermistor mount is determined by measuring the total RF power dissipated in the mount and the substituted dc power simultaneously[2]. In resent experiments, significant difference of the effective efficiency of WR-22(33~50GHz) thermistor mount in different relative humidity was observed. The effects of humidity on the efficiency of thermistor mounts in recent experiments can be about 9 times the *k*=1 uncertainty. We designed and made experiments to research the effects of humidity on thermistor mounts.

II. MEASUREMENT METHODOLOGIES

The microcalorimeter measures the effective efficiency of a thermistor mount through determining the ratio of the changes in the DC power (or DC substitution power) to the absorbed microwave or millimeter-wave power[3]. The thermistor mount is applied DC power by type 4 power meter to keep its resistance constant.

According to the definition, the effective efficiency of a thermistor mount can be determined by a measurement of the substituted DC power $P_{DC,sub}$ with respect to the total absorbed RF power $P_{RF,abs}$.

$$\eta_e = P_{dc,sub}/P_{RF,abs} \tag{1}$$

The effective efficiency η_e of the thermistor mount at each frequency of interest can be calculated using the following formula (2)

$$\eta_e = g\{1-(V_2/V_1)^2\}/\{e_2/e_1-(V_2/V_1)^2\} \tag{2}$$

Here V_1 and e_1 are the output voltages of the power meter and thermopile with only the DC applied to the mount, and V_2 and e_2 are the same voltages with both the RF and DC applied[4]. g is the correction factor of the microcalorimeter, and can be measured and characterized through inserting a foil short between the test port and the mount in the microcalorimeter. Correction factor g is used for correcting other location's millimeter-wave power loss in microcalorimeter, which contributes to thermopile output and affects the effective efficiency calculation[5]. Moreover, g is fixed value for the same microcalorimeter and thermistor mount at the same frequency.

III. PRELIMINARY RESULTS

The temperature in the laboratory of our experiments was controlled within 23±1℃, and the microcalorimeter was put in water bath in which the temperature stability can reach 800 μ℃ per day to decrease negative effect of temperature noise. Additional, a copper block(Average Temperature Block) was used to eliminate the effect of the lab thermal noise from leads[6].

In the past, relative humidity(RH) in the lab was not controlled. In fall and winter, relative humidity in the laboratory was about 10%~20%RH without control, except for brief excursions. Recently, we achieved relative humidity control by a humidifier and air-conditioners, and relative humidity can be controlled within 50% ± 5 %.

We made measurements of a WR-22 thermistor mount(No.2206, HUGHES Thermistor Mount) with the same Core (No.Core1) and thermistor mount connection in 20% and 50% RH level. As a key part of the microcalorimeter, the Core placed between the waveguide and the thermistor mount is used to obtain the thermal information of the thermistor mount through the thermopile in the measurement. The Core structure is showed in the Fig.1.

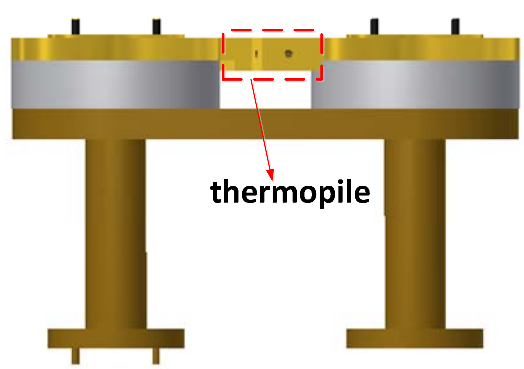

Fig. 1. The Core structure

Another experiment with a new Core(No.Core3) which was

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manufactured by another factory was made in the same experiment condition. The results of the measurements are showed in Fig.2. It is showed that the efficiency differences at 46, 49, 50GHz is far larger than the *k*=1 uncertainty, and the max difference at 49GHz is about 9 times the *k*=1 uncertainty. The changes of effective efficiency η with Core1 and Core3 in different humidity level are very similar. The significant difference of efficiency between Core1 and Core3 at 35GHz is result of different manufacturers of Core1 and Core3, and it can be corrected with correction factor.

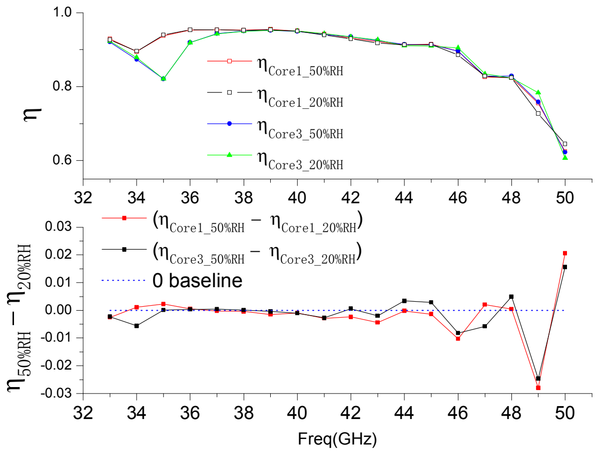

Fig. 2. Effective efficiency of 2206 with Core1 and Core3 in about 20% and 50% RH level

We kept 2206 in about 20% relative humidity level for up to 24 hours and made it hermetically sealed to avoid the effects of humidity on 2206. Measurements of 2206 with Core1 in 20% and 50% relative humidity levels were made, and the result is showed in Fig.3.

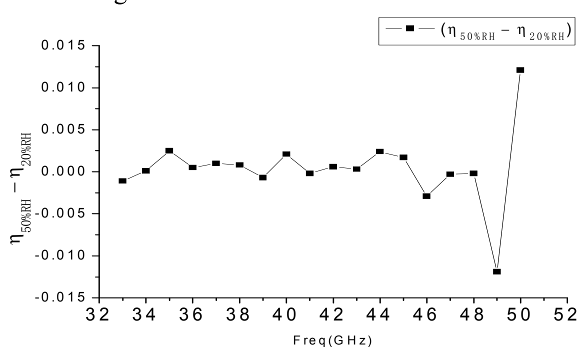

Fig. 3. Difference in effective efficiency of the hermetically sealed thermistor mount(2206) with Core1 in 20% and 50% humidity level

The difference in effective efficiency measurements of hermetically sealed 2206 was less than half of that in Fig.2, and it may be caused by the hermetic seal measure.

CONCLUSION

A preliminary conclusion can be obtained that the effects of humidity on thermistor mounts can result in the changes of effective efficiency. While the humidity impacts on microwave transmission device is not the main reason of these changes. The next step of the research will focus on the further study on the principles and detailed ways of humidity influences on thermistor mounts.

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