

## RM2610 Probe Maintenance Guide

### Introduction

Thank you for using the RM2610 electrode resistance measurement system.

This system is the first of its kind in that it is able to separately obtain the composite layer resistivity and interface (contact) resistance between the composite layer and current collector of the electrode sheet for lithium-ion secondary batteries. This revolutionary capability enables users to perform rational and quantitative evaluation of electrode sheets and provides a new index for screening and quality evaluation.

A proper understanding and use of this product is essential for obtaining correct measurement results. This guide explains the proper probe maintenance procedures for the following purposes.

- Improving measurement accuracy by keeping the probes in proper condition
- Prolonging the lifespan of the probes
- Being able to quickly notice when it needs to be replaced

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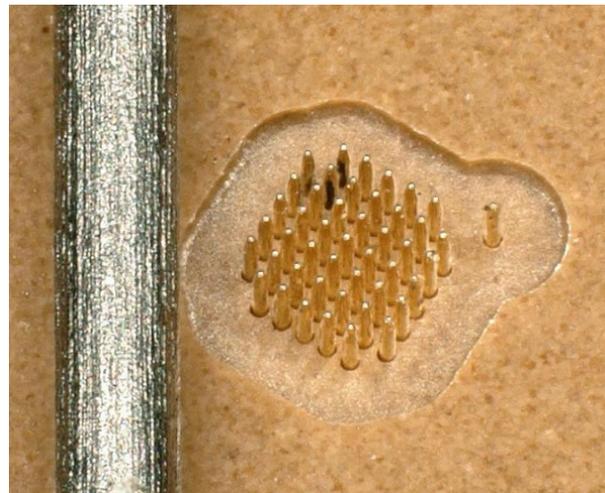
1. Overview of the Electrode Resistance Measurement System and the Probe's Role



The RM2610 calculates the composite material layer's resistivity and interface resistance from the voltage or electric potential (hereafter referred to as "potential") of the electrode sheet. It measures the potential by applying a constant current through the electrode sheet, then measuring the potential at multiple points of the surface.

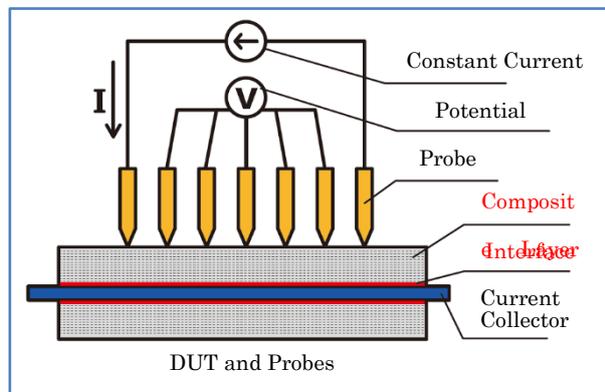
The needle-like components that directly contact the electrode sheet and send currents or measure the potential are called "probes." In this product, 46 probes are equipped at the tip (bottom) of the test fixture RM9004 (see the photo on the right).

The probes are arranged in a grid pattern at intervals of approximately 120 μm and the tips of the needles are φ75 μm. Although it protrudes about 250 μm from the contact surface, it is a special probe with a spring-like property. Such probes are known as a "buckling probes." It is designed to not stick into the electrode sheet (although it may, depending on the softness of the composite



46 Probes

To the left is a 0.5 mm mechanical pencil lead



layer). Since each probe has a spring-like quality, it contacts the electrode sheet with an appropriate force while simultaneously adjusting to the irregularities in shape of the electrode sheet.

Since the probes are very small and thin, they must be handled with great care. And for accurate measurement, daily probe maintenance is essential.

## 2. Daily Inspection

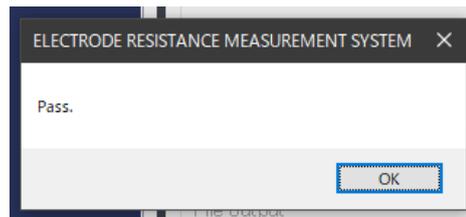
In order to quickly find probe contact failure, insulation failure, probe abnormalities, etc., please perform inspection. Inspections can be divided into two major types.

- “SHORT” and “OPEN” Inspection: checking for electrical conduction/insulation
- Probe Tip Observation: visually checking the probe status

We recommend these two inspections before the first use of the day.

### A. “SHORT” and “OPEN” Inspection

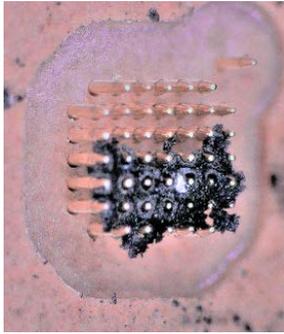
Setting the "probe inspection board" (included with the RM9004) in the place of an electrode sheet, perform the “SHORT” inspection and “OPEN” inspection of the electrode resistance calculation software



RM2612. (Refer to the RM2610 instruction manual.) The inspection result will be displayed in a dialog box. If the "Pass" dialog box appears in both inspections, the probe contact is good.

If the "Abnormal contact resistance" or "Abnormal insulation resistance" dialog box appears, repeat the check several times. If the error still occurs, perform the next inspection, "2. B. Probe Tip Observation" and maintenance methods, "3. How to Maintain the Probes," outlined below. After completing those steps, execute “SHORT” inspection and “OPEN” inspection again.

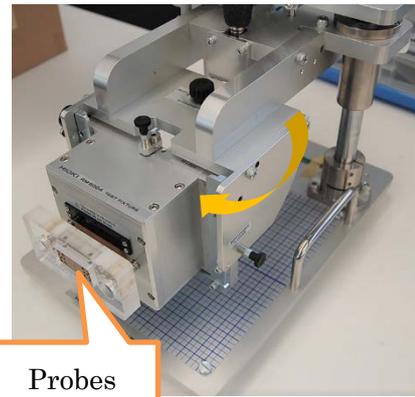
## B. Probe Tip Observation



Even if the “SHORT” inspection and “OPEN” inspection results are “Pass,” electrode material may be attached to the probe tip (left figure). It is highly possible that these materials will cause contact failure and insulation failure, and will adversely affect the performance of the probe. Thus, it is necessary to remove them before measurement.

Also, confirm by observation that the probe is not broken or deformed. For checking, use the tilt mechanism of the press unit RM9003 to direct the probe tips of the RM9004 to the front for easier observation. (Refer to the RM2610 and RM9003 instruction manuals for tilt mechanism operation.)

With the tip of the probe facing you, use a magnifying glass or similar tool to check the probe for breakage, deformation, and clogging with electrode composite material. If you find any abnormality, please follow "3. How to Maintain the Probes."



### [Note]

With this system, it is still possible to measure even if a few probes are broken. For such situations, refer to “4. Error Data Removal Function”. If many contact fails occur or there is too much damage, the probes will need to be replaced.

### 3. How to Maintain the Probes

This section describes the cleaning methods for removing electrode composite material and other material attached to the probe. This will reduce contact failure and insulation failure, and will remove factors that adversely affect the probe operation.

#### A. Air Cleaning [Recommended]

As a general rule, compressed air is recommended for cleaning the probe. When contact failure or insulation failure occurs, and during daily inspection (even when there is no error), please perform cleaning with compressed air. Air compressors or similar devices can be used to apply compressed air to the probe in order to blow off the attached electrode composite material. There are no particular rules regarding the direction in which air is applied, but please note the following points.

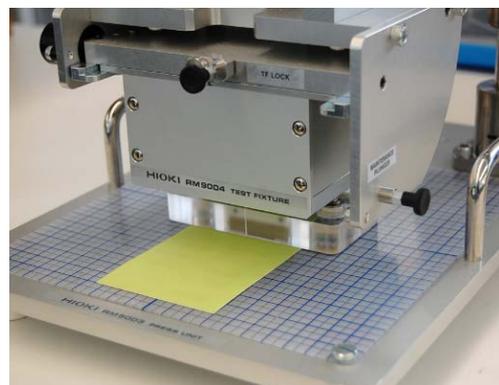
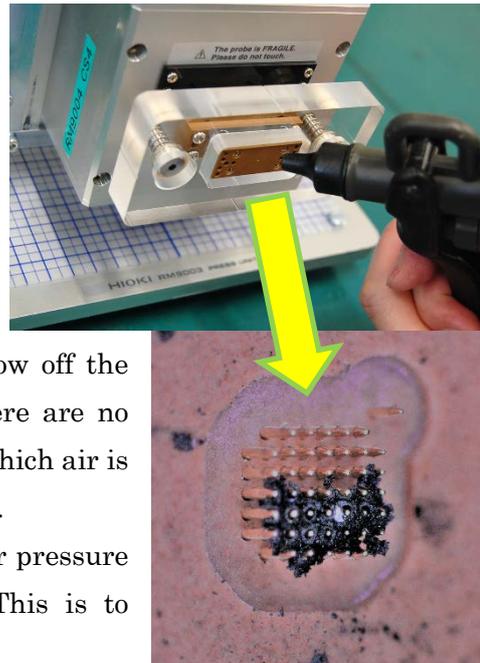
- For safety purposes, please keep the air pressure below 207 kPa (2.1 kgf/cm<sup>2</sup>, 30psi). This is to prevent air embolism accidents.
- Use protective goggles and a dust mask to protect yourself from the electrode material particles blown by the compressed air.
- Hold the air compressor firmly before discharging the air so that the gun nozzle of the air compressor does not hit the probes.

This cleaning method will improve most “SHORT” and “OPEN” inspection errors. If it does not improve, proceed to the next sections, B and C.

#### B. Cleaning Film

Using a cleaning film to remove insulating material on the probe tip may restore electrical contact.

The surface of the cleaning film should be coated with a fine polishing agent. Placing it on the measurement stage and moving the test fixture up and down onto it several times will clean the probe tips. However, as the polish



coating is an abrasive material, excessive use is not recommended. Do not perform it unless there is contact error.

Hioki recommends the cleaning film "Cleaning Film Type BL" from 3M Japan Co., Ltd.

Although cleaning films can be effective against errors during "SHORT" inspection, it is not expected to be effective against errors during "OPEN" inspection.

For the reasons for poor electrical contact, refer to "6. Reasons for Probe Contact Failure [Note]".

### C. Cleaning with a Brush

This method should be considered a last resort. Cleaning with a brush is generally not recommended.

Please do so at your own risk.

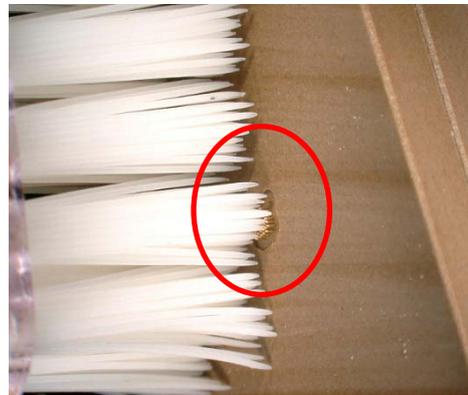
A brush should only be used when electrode composite material fail to come off with compressed air and a cleaning film.

For this method, use a soft brush whose tip is thin and dense in the following way:

1. Slowly apply the brush at a vertical angle to the probes
2. Move the brush in a small circle to scrape out the electrode material

Do not tilt the brush at an angle. When a force is applied to the probes from the side, there is a high probability that probes will break.

Although the use of a brush is not recommended, if a brush is used, we would recommend Sunstar Dental Brush "Gum Dental Brush # 166 [Super Taper Hair Series]".

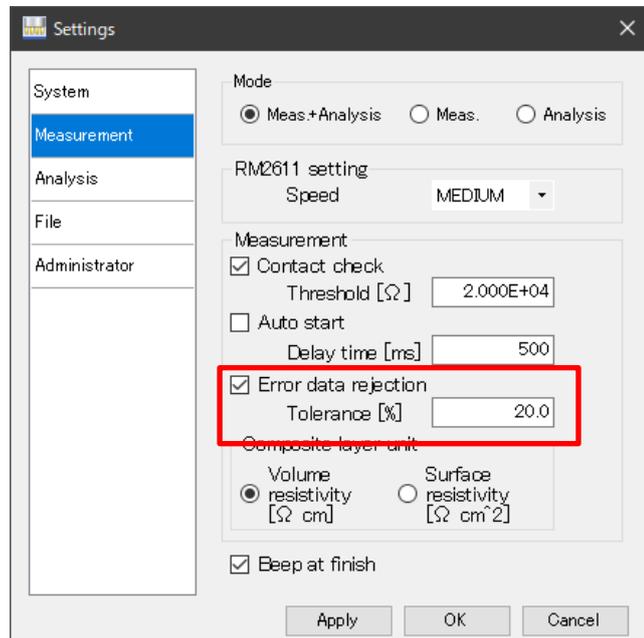


#### 4. Error Data Removal Function

Contact may not be improved even after cleaning. This system is equipped with an "error data removal function." As long as there are only a few probes that have poor contact causing the contact error, this function is able to delete the error data and perform the necessary calculations.

However, reliability of the results will be lower in such situations compared to when all probes are functioning properly. Although

the reliability goes down, measurement of electrode sheets with small variation will render comparable measurement results. The permissible rate [%] can be set with the PC software, but 20% or less is recommended.



#### 5. Countermeasures for When Contact Failure Occurs Frequently

If contact failure or insulation failure occurs frequently even after performing probe cleaning, it is necessary to replace the probes. For probe replacement, please contact the sales subsidiary, branch office, or distributor of Hioki E.E. Corporation from which you purchased the system. After contacting the seller, you will receive information as to where to send your unit for repairs. After receiving the unit, the Hioki factory will replace all probes and wash the plate, re-assemble and inspect, and then send it back to you. (The above services are at the expense of the user. Approximately 5 working days are required for the tasks of receipt to inspection).

#### 6. Reasons for Probe Contact Failure [Note]

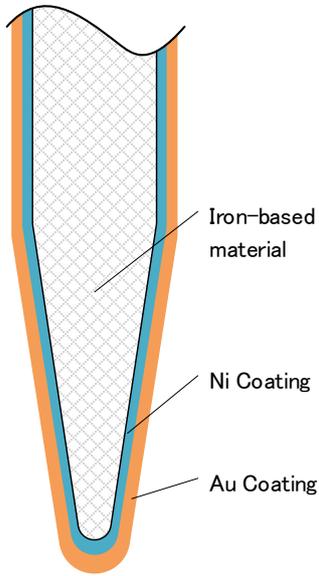
If something that does not conduct electricity adheres to the tip of the probe, it will cause poor contact. In this system, possible causes for contact failure are adhesion of insulators, and wear and corrosion of the probe tip.

##### A. Adhesion of Insulators

If the electrode composite material adheres to the tip of the probe, although not always the case, it will be an insulator that blocks the flow of electricity. This will

cause a contact error at the time of inspection, so perform the recommended cleaning (e.g. compressed air).

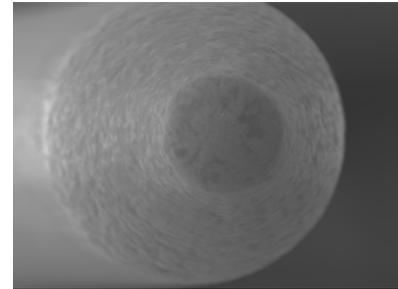
B. Corrosion of the Probe Tip



The base material of the probe is industrial steel. In its shipment state, it has two layers of coating on it. The coating improves electrical contact and protects against corrosion.

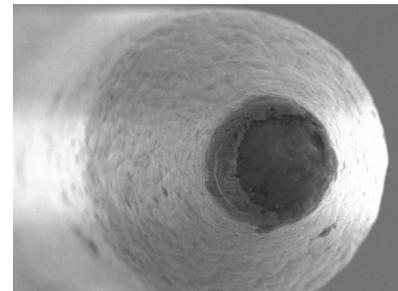
Composite material of electrode sheets are generally harder than this coating, as such, each use gradually scrapes way at the coating.

The picture above shows the tip of an unused probe observed by an SEM (Scanning Electron Microscope).



The picture below is a

SEM image of a probe tip after several hundred measurements. The base material is exposed because the tip is scraped, but this alone does not cause contact failure. As a result of Hioki's observation, we believe that oxidation formed on the tip surface of this iron-based material becomes an insulating substance, resulting in contact failure.



Therefore, removing this oxidation may restore contact. For this please try "3. C. Cleaning Film."

[Note]

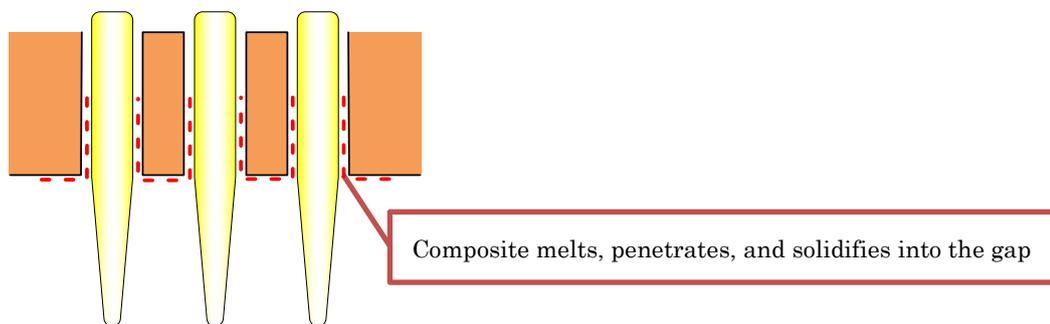
Although electrode composite material clogged between the probes is considered unrelated to the contact failure at the probe tip, it may cause insulation failure between the probes or adversely affect the performance of the probes. Due to these reasons, it needs to be removed.

7. Other Points of Caution

Here are some cautionary points about the probe.

- The probes are very fine and sensitive. Please don't touch them.

- If the tip of the probe is clogged with electrode composite material, do not wipe it with substances such as fabric. The probe will almost certainly break.
- Please be careful not to bump the electrode sheet during measurement or touch the probes with an air compressor gun nozzle during cleaning as these actions would damage the probes.
- Do not wash with liquid. If the probe tip is cleaned with a liquid such as alcohol, water, or another solvent, the electrode composite material will melt and penetrate into the gap (see the figure below), and solidify. This will cause the probes to malfunction.



- Storage environment:  
The storage environment for the RM9004 test fixture is 0°C to 50°C, 80% rh or less, and with no condensation. Condensation can damage the probes and as such should be stored in a dry environment.
- Perform “SHORT” inspection and “OPEN” inspection before the first measurement of the day.
- Dirt on the probe tip:  
Clean the tip of the probe after and within the same day of measurement. Leaving material on the probe for a long time makes it harder to remove.
- It is not recommended to measure an electrode sheet that is soft enough for the probe to pierce. It will damage the probe. In addition, the measured value of such electrodes will be unstable, which will in turn affect the calculated value.
- The probe is a consumable item:  
The probes used in this system can withstand hundreds of thousands of cycles if it is buckled in the vertical direction. However, the degree of wear and corrosion of the tip will vary depending on the measurement target. If the contact does not recover even after using cleaning methods described in this guide, please contact Hioki E.E. Corporation for probe replacement.