COULOSCOPE® CMS and COULOSCOPE® CMS STEP.

Simultaneous Measurement of Coating Thickness and Electrochemical Potentials according to the Coulometric Method.

COULOSCOPE® Test Instruments.

The COULOSCOPE® instrument series operates according to the coulometric method by deplating according to EN ISO 2177 and impresses with its unique design and capabilities. The appealing design, the big LCD display and the clearly arranged keyboard – these are the prominent external features of the COULOSCOPE® series. Just as important, however, is their simple operation, based on the menu-driven operator prompting. This allows for problem-free and quick setting of the instruments to new measurement applications. Approx. 100 predefined applications, from single coatings like such as zinc on steel up to triple coatings like chromium on nickel on copper on plastic are at your disposal.

COULOSCOPE® CMS

It is the ideal instrument for measuring the thickness of virtually any metallic coating on metallic or non-metallic substrates, especially also of multiple coatings, if non-destructive methods cannot or need not to be used.

COULOSCOPE® CMS STEP

In addition to the coating thickness measurement corresponding to the COULOSCOPE® CMS, the COULOSCOPE® CMS STEP provides functions for the STEP test measurement according to ASTM B764 - 94 and DIN 50022. The COULOSCOPE® CMS STEP is ideally suited to measure in a simple standard-conforming manner the individual coating thicknesses and the potential differences of multiple nickel coatings.

Example for a measurement system with COULOSCOPE® CMS instrument and measurement stand V24

Coulometric Coating Thickness Measurement (EN ISO 2177).

Measurement principle

The instrument series utilizes the coulometric method according to EN ISO 2177. The metallic coating is removed from its metallic or non-metallic substrate by the passage of electric current under controlled conditions – in fact, the reverse of the electroplating process. The electric current applied is directly proportional to the metal mass to be deplated. The result is a clear correlation between deplating time and coating thickness, provided the deplating current and the deplating area remain constant.

$$th = \frac{eÄ \cdot I \cdot \gamma \cdot t}{A \cdot \rho}$$

th: coating thickness
eÄ: electrochemical equivalency [g/As]
I: deplating current [A]
γ: electrolytic efficiency
t: deplating time [s]
A: deplating area [cm^2]
ρ: density of the deplating coating material [g/cm^3]

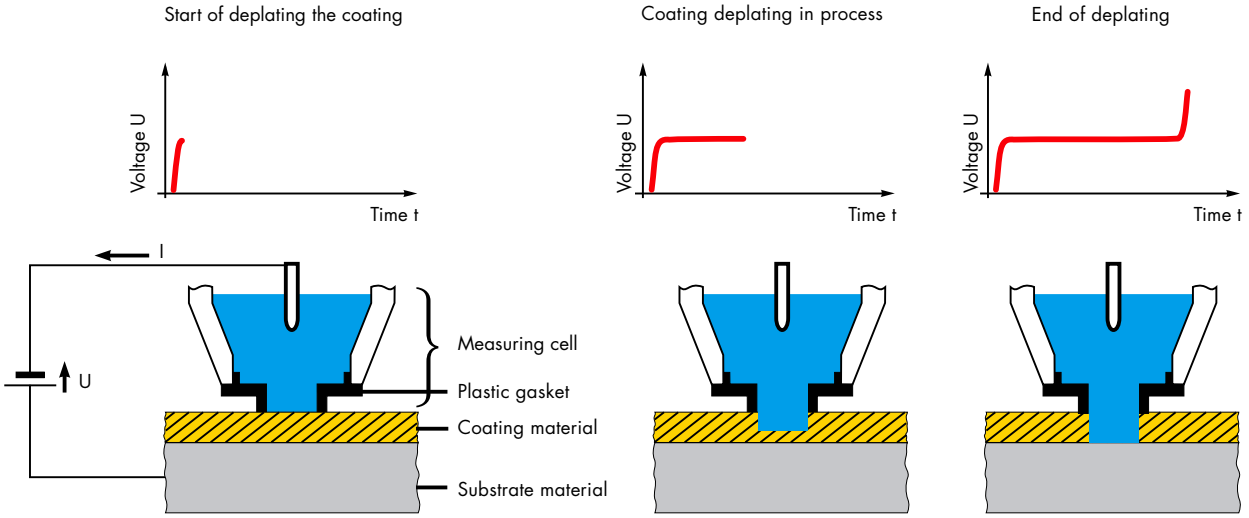
A measuring cell – comparable to an electrolytic miniature bath – is used to deplate the coating. The measurement area is defined by a plastic gasket placed on the cell. The electrolytes used for the electrolysis are formulated for the various coating materials so that deplating occurs only when an electric current is applied. The deplating process is controlled by the electronics of the COULOSCOPE® instrument. A pump moves liquid electrolyte in the measuring cell allowing fresh electrolyte to be present at the deplating area.

Applications

The coulometric method is one of the simplest methods for coating thickness measurement. It is suited for both production monitoring in the electroplating industry and incoming inspection on finished parts. With a relatively small investment, many coatings that occur in typical applications can be measured. Aside from the X-ray fluorescence method, the coulometric method is the only other method for fast coating thickness measurement for multi-coating systems such as Cr/Ni/Cu on steel or plastic substrates (ABS). Of course, single and dual coatings, such as zinc on steel or tin on nickel on silver can be measured with the COULOSCOPE® series without problems as well.

The COULOSCOPE® instrument series guarantee accurate measurements of metallic coatings in the range of 0.05 – 40 µm (0.002 – 1.6 mils).

Schematic presentation of the coulometric method



STEP-Test Measurement (ASTM B764 – 94 and DIN 50022).

Presentation of a potential profile on the display

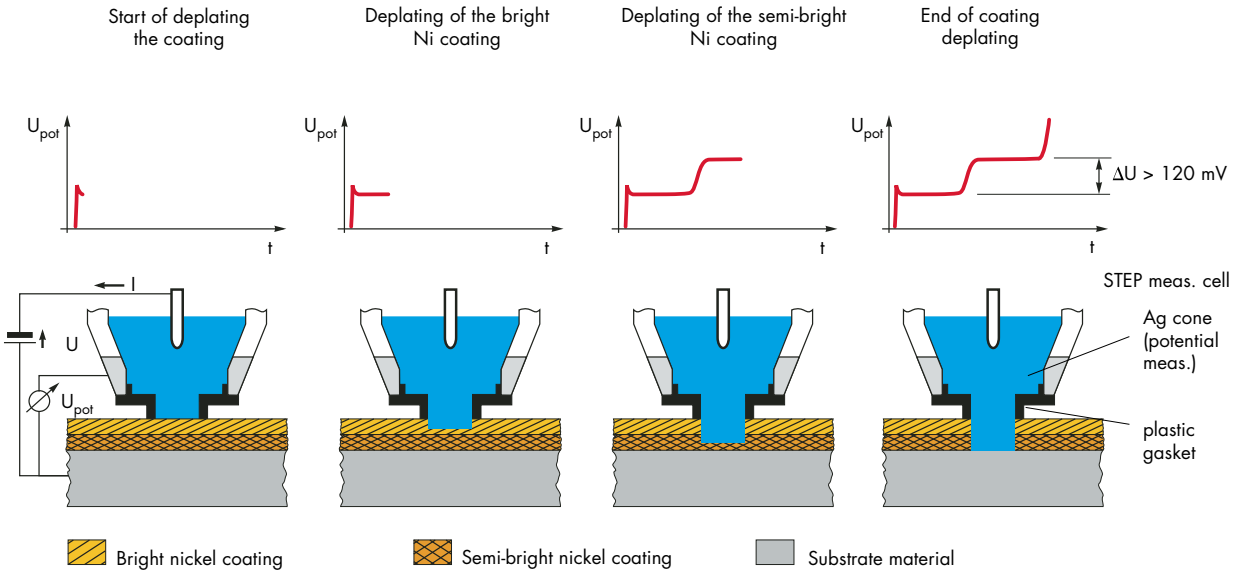
Measurement principle

STEP-Test (Simultaneous Thickness and Electrochemical Potential determination) is a measurement method that has been standardized for a long time to determine simultaneously individual coating thicknesses and the electrochemical potential differences between individual coatings of a nickel coating system. The coating thickness measurement is carried out according to the coulometric method as described on page 3. The potential profile is captured using a silver reference electrode coated with AgCl. The potential profile is shown on the display and the individual coating thicknesses and the potential differences can be determned through respective cursor positioning on the plot.

To obtain comparable measurements with the potential measurement method, the reference electrode must always have the same distance from the specimen. This is accomplished using a special measurement cell*. The silver reference electrode is designed as a cone-shaped ring electrode and forms the lower housing component of the measurement cell, where only the necessary measurement cell gasket is placed. This design of the measurement cell ensures a consistently uniform distance between the reference electrode and the specimen.

* Property rights applied for

Schematic presentation of the STEP test method shown with the example of duplex nickel coatings



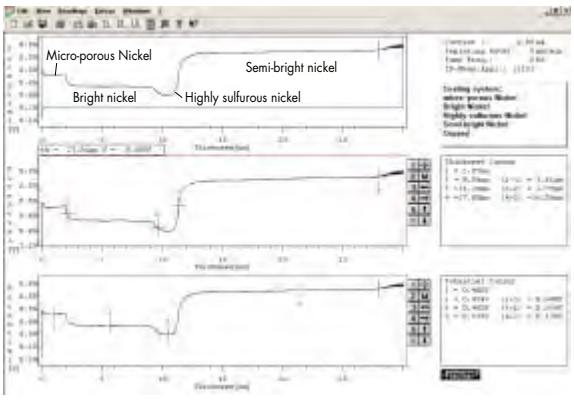
Applications

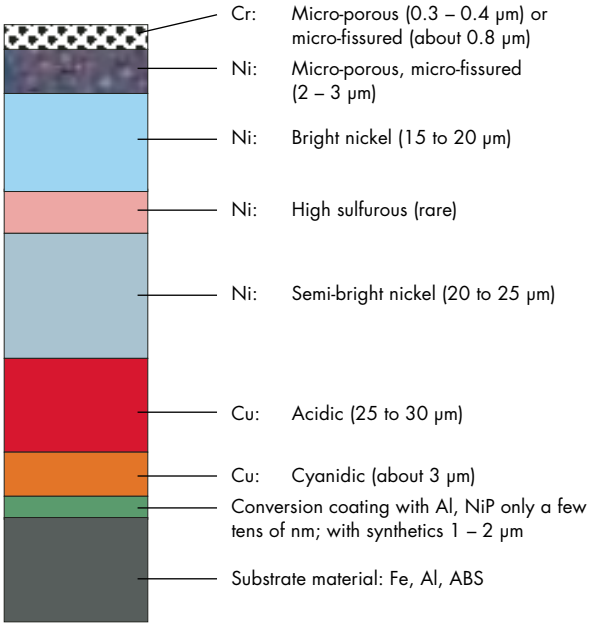
Quality control of multiple nickel coatings requires measurement devices that can check the thickness and the electrochemical potential immediately following the coating procedure. The COULOSCOPE® CMS STEP measuring system, which due to its simple operation and uncomplicated handling of the reference electrode is suitable for applications in the harsh environment of electroplating plants, has been developed for this purpose. Electrolytic nickel-plating is used for decorative corrosion protection and for improving mechanical surface properties, e.g., hardness. In particular in the automotive industry, nickel-plated components must meet high demands with regard to corrosion behavior. Single nickel coatings are not suited for this purpose. Very complex coating systems are, therefore, being developed, which consist of two, three or even four different nickel coatings as well as additional coatings of chromium or copper.

Evaluation and data storage using STEP-View

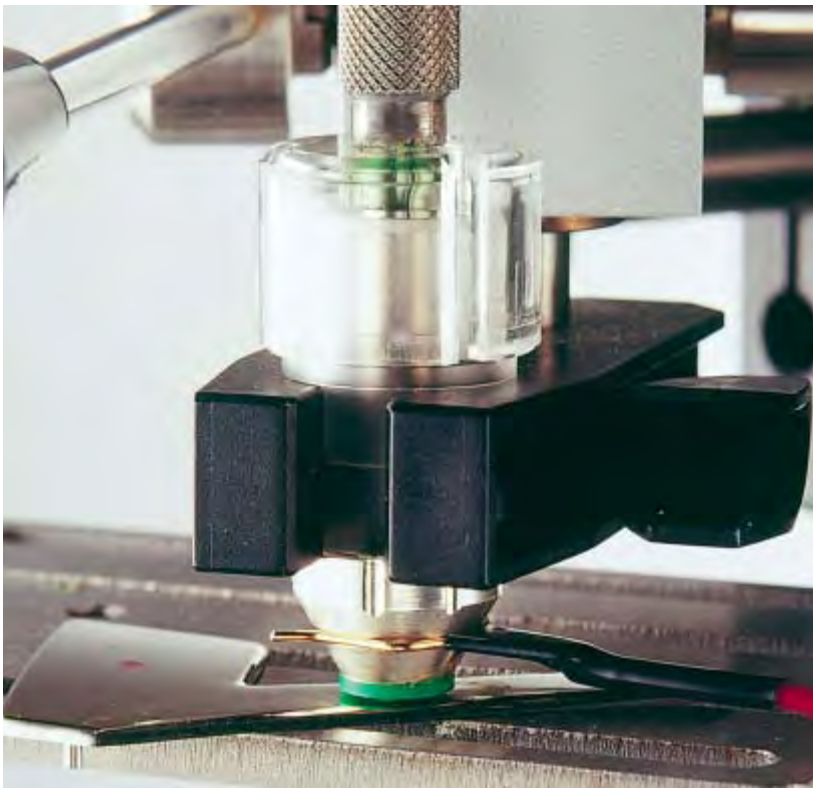
The PC software program STEP-View is available to save and conveniently evaluate the measured potential plots. It is shipped as part of the standard equipment of the COULOSCOPE® CMS STEP. However, evaluations can be carried out also directly at the instrument.

In the STEP-View program, the measured potential profile can be read from the instrument with a click of the mouse button. The determination of the coating thicknesses and of the potential differences occurs in two separate diagrams. The interesting values can be determined easily by positioning up to 5 markers at the relevant sections of the plot. The data can be exported to an Excel spreadsheet, the plots can be saved in popular graphic formats and extensive printform templates can be set up.





Basic structure of a coating system with 4 nickel coatings



STEP measuring cell V24/V26 STEP measuring stand V24

Features, System Overview.

General features

- Large size display of measurement values
- Simple choice of deplating rate and test area size
- Available test area sizes: ø 3.2 (128), 2.2 (88) and 1.5 (60) mm (mils). 0.6 mm (24 mils) additional for stand V18
- Deplating rate adjustable between 0.1 and 50 µm/min
- Stand V18: controlled filling and emptying of the cell by means of a pump. Multiple measurements with one cell filling and warning when the electrolyte becomes saturated
- Graphical display of the cell voltage on the LCD screen
- Zoom function to magnify interesting plot sections
- Interfaces for PC and printer connection
- Output for analog chart recorder for the cell voltage
- Selectable measurement units: µm or mils
- Selectable languages: German, English, French, Italian, Spanish
- Storage of all application parameters when switching off the instrument

Special features of version COULOSCOPE® CMS

- Evaluation of measurement data in table or graphic format
- Storage measurement data when switching off the instrument
- Automatic or manual measurement switch-off

Special features of version COULOSCOPE® CMS STEP

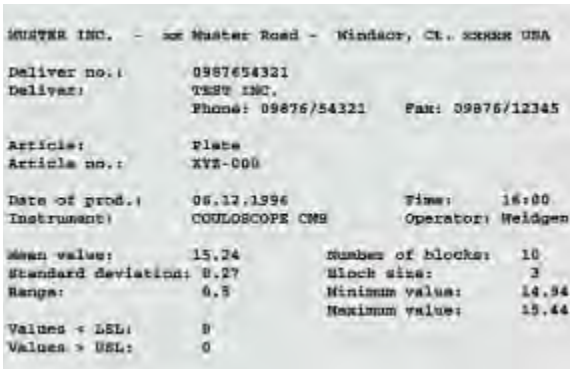
- Adjustable deplating amperage
- Determination of the coating thicknesses and potential differences using the cursor
- Automatic measurement sequence for conditioning the silver reference electrode (generation of the required AgCl coating)
- Manual measurement switch-off

System overview

To build a functioning measurement system, the COULOSCOPE® CMS or COULOSCOPE® CMS STEP requires a measurement stand with attached measuring cell (STEP measuring cell).

Different measurement stand models including measurement cells are available for the various measurement applications.

COULOSCOPE® CMS
Example of a measurement screen for a triple coating measurement application. The left half of the display features the measurement application in a graphical format with information regarding coating and substrate material, required electrolyte and color code of the plastic cell gasket to be used



COULOSCOPE® CMS: Example of a user specific printform

V18

V24

V26

V27

PC
to evaluate and store data and to create custom print-form templates.

Printer
to document the measurement results.

Measurement Applications.

Standard features of the COULOSCOPE® instruments:

- 73 stored standard measurement applications for most metal coatings
- 14 stored standard measurement applications for coating thickness measurements on wires
- 2 stored standard measurement applications for STEP-Test measurements (only for instrument model CMS STEP).

If a standard measurement application is not available for your particular material combination, a special measurement application can be defined that is specifically adapted to your particular situation.

Calibration

During calibration, a correction factor (calibration factor) is determined. This correction factor may be required due to production tolerances in the cell gasket diameter, and to variations in coating material density or alloy composition of the coating material. For STEP-Test measurements a factor can be entered.

Applications

Applications are areas of memories where measurement application specific parameters (such as standard or special measurement application, calibration factor, unit of measurement, etc.) and the measurement data are stored. Applications can be copied, edited and deleted.

Standard measurement applications and electrolytes

A total of 89 standard measurement applications are available for various applications. The following table lists a selection of possible measurement applications. For multi-coating systems, the respective coating underneath the coating to be measured is considered the substrate material.

Coating materials	Substrate materials	Smallest measurable coating thickness in µm (µ")									Largest measurable coating thickness µm [mils]
		0.015 (0.6)	0.03 (1.2)	0.07 (2.8)	0.15 (6)	0.3 (12)	0.7 (28)	1.5 (60)	3 (120)	7 (280)	
		Deplating rate [µm/min]									
		0.10	0.20	0.50	1.00	2.00	5.00	10.0	20.0	50.0	
Ag	Fe, Ni, Al, non-metals					F4	F4	F4	F4	F4	50 (2)
	Cu				F8	F8	F8				
								F18	F18	F18	
	Cu, Ms				F17	F17					5 (0.2)
Cr	Fe, Ni, Al, non-metals	F1	F1	F1	F1	F1	F1	F1	F1		50 (2)
	Cu, Ms	F9	F9	F9	F9	F9	F9	F9	F9		
Cu	Fe, Ni, Al, non-metals				F4	F4	F4	F4	F4		50 (2)
	Ms, Zn, Zn die casting					F5	F5				10 (0.4)
Ms	Fe		F4	F4	F4	F4	F4	F4	F4		50 (2)
Ni	Fe, Al, Cu, Ms, non-metals					F6	F6	F6	F6		50 (2)
Ni-Fe	Fe, Cu, Ms, Zn, Sn						F6	F6	F6		
Ni electroless	Fe, Al					F7	F7	F7			
Pb	Fe, Cu								F4		50 (2)
Sn	Al				F1	F1	F1	F1	F1		50 (2)
	Fe, Ni, Cu, Ms, non-metals				F9	F9	F9				
							F12	F12	F12		
$Sn_{60}Pb_{40}$	Fe, Ni, Al, Cu, Ms, non-metals				F4	F4	F4	F4	F4		50 (2)
Zn	Cu, Ms					F10	F10	F10	F10		50 (2)
	Fe, Ni, Al					F11	F11	F11	F11		
Wire measurement overview table											
Ag	Cu wire					F8					4 (0.16)
Cu	Fe-, Ni wire		F4	F4	F4						2 (0.08)
Ms	Fe wire				F4						2 (0.08)
Ni	Fe wire					F6	F6				10 (0.4)
Sn	Cu wire					F12	F12				10 (0.4)
$Sn_{60}Pb_{40}$	Cu wire				F4	F4	F4	F4			20 (0.8)
Zn	Fe wire						F11				10 (0.4)
STEP-Test measurement overview table											
Multiple nickel coating system as shown in the figure on page 5							F22		F22		40 (1.6) coating

F... : Electrolyte type suitable for deplating the coating