南京邮电大学
Nanjing University of Post & Telecom

物理实验教学中心

Physics Expeiment Center

Dielectric constant measurement

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Purposes:

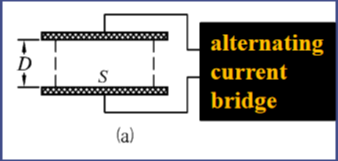
1、Handle the principles and method of the measurement of dielectric constants.

2、Learn the method of data processing.

Principles:

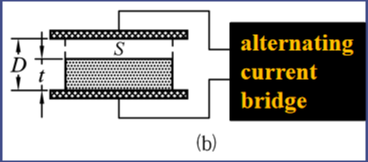
1、Measure the relative dielectric constant of solid dielectrics by alternating current bridge

In the air



$$C_1 = C_0 + C_{B1} + C_{F1}$$

Insert dielectric sample



$$C_2 = C_C + C_{B2} + C_{F2}$$

We have these functions:

$$C_0 = \frac{\varepsilon_0 S}{D}$$

$$C_C = \frac{\varepsilon_r \ \varepsilon_0 \ S}{t + \varepsilon_r \ (D\text{-}t)}$$

$$C_{B1} = C_{B2}$$

$$C_{F1} = C_{F2}$$

$$C_C = C_2 - C_1 + C_0$$

$$\varepsilon_r = \frac{C_C \cdot t}{\varepsilon_0 \ S - C_C \ (D - t)}$$

2、Calculations of air dielectric constant and capacitance:

Vacuum dielectric constant ε_0 , S_0 is plate area, D is distance between plates, the capacitance C is shown as:

$$C = \frac{\varepsilon_0 S_0}{D} + C_F$$

Set $C = y$, $\frac{1}{D} = x$

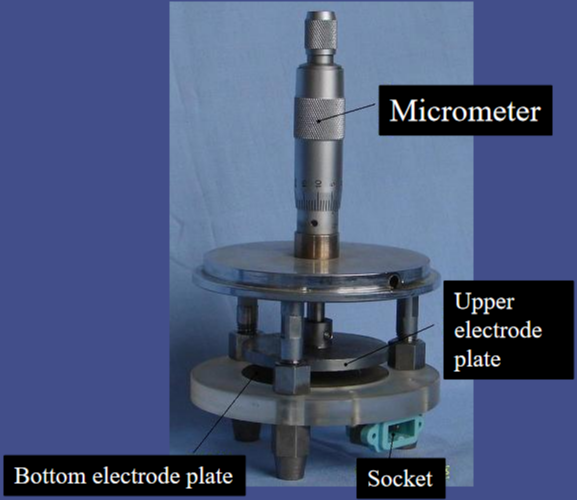
$$y = a + bx$$

We got $a = C_F$, $b = \varepsilon_0 S_0$

Finally, we have $\varepsilon_0 = b/S_0$

Instruments:

1、 Solid electrode



2、Alternating current bridge

We choose 10kHz

and read from

'DISPLAY A' section.

3、 Solid dielectric sample

Solid samples are disk-shaped PTFE plastics, the material with high temperature resistance, corrosion resistance, high dielectric strength characteristics.

Steps and Contents:

1、 Measure the dielectric constant of solid dielectrics by alternating current bridge

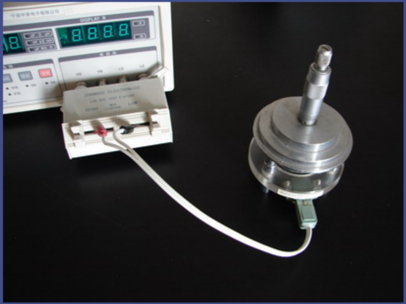
(a). Measure the diameters of the sample as ***d***, three times using Vernier caliper. Measure the thickness of sample as ***t*** three times using micrometer.

(b). Let the two plates touch each other, and read the starting value of the micrometer as $\boldsymbol{D_0}$.

(c). Set the distance of the plates as 5.000mm. Note that the real value in micrometer should be 5.000mm + D_0. Read the capacitance data from 'DISPLAY A' section as C1.

(d). Insert the sample carefully, read the capacitance again as C2.

(e). Repeat steps (d) and (e) twice.



2、Measure the vacuum dielectric constant and capacitance

Remove the sample, set the palates distance to **1.000、1.100 … 1.900 mm, and**

Read the corresponding capacitance ***C***.

$$C = \frac{\varepsilon_0 S_0}{D} + C_F$$

Set x = 1/D， y = C

Calculate C_F and ε_0 using origin software.

Data processing:

Table I

Starting value D_0 = *0.000* mm, Distance D = **5.000** mm

$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

	D/mm	d/mm	t/mm	S/mm^2	C_0/pF	C_1/pF	C_2/pF	C_C/pF	ε_r
1	5.000			$\pi(d/2)^2=$					
2									
3									
Average	-								

d: diameter of sample,
t: thickness of sample,
S = $\pi(d/2)^2$

$$C_0 = \frac{\varepsilon_0 S}{D}$$

$$C_C = C_2 - C_1 + C_0$$

$$\varepsilon_r = \frac{C_C \cdot t}{\varepsilon_0 S - C_C (D - t)}$$

1 F=10^{12} pF,
1 m=10^3 mm

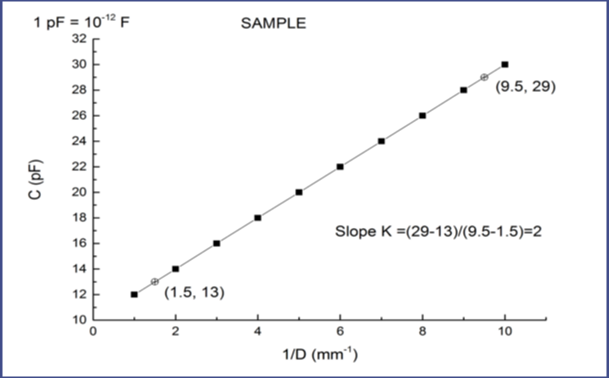
Table II

D/mm	1.000	1.100	1.200	1.300	1.400	1.500	1.600	1.700	1.800	1.900
1/D(mm-1)										
C/pF										

$$C = \frac{\varepsilon_0 S_0}{D} + C_F$$

Set $x = 1/D$, $y = C$,
calculate ε_0.

The Slope $K = \varepsilon_0 S_0$,
$\varepsilon_0 = K / S_0$
The Intercept is C_F.
Note: $S_0 = 21.61\ cm^2$.



Here is the weblink to download the slide:
https://github.com/bliseu/phylab/

1. Please finish the table I and II in the slide.
2. Plot a *1/D-C* line, determine the slope ($K = \varepsilon_0 S_0$) and intercept (C_F) of the line, then calculate ε_0 and compare it with the theoretical value ($\varepsilon_0 = 8.85 \times 10^{-12} F/m$).
3. Complete the report.

The DEADLINE is April 4, 2024.

END