

物理实验教学中心

Physics Experiment Center



Dielectric constant measurement

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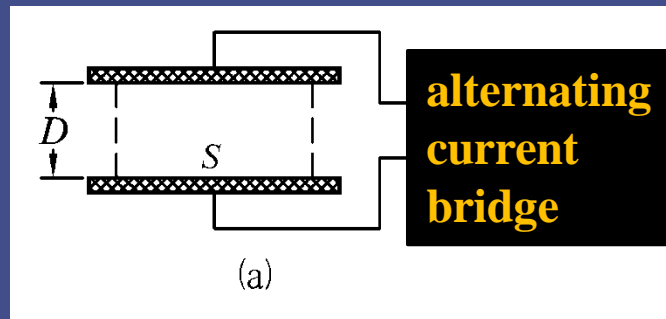
Purposes:

- 1、 Handle the principles and method of the measurement of dielectric constants.**
- 2、 Learn the method of data processing.**

Principles:

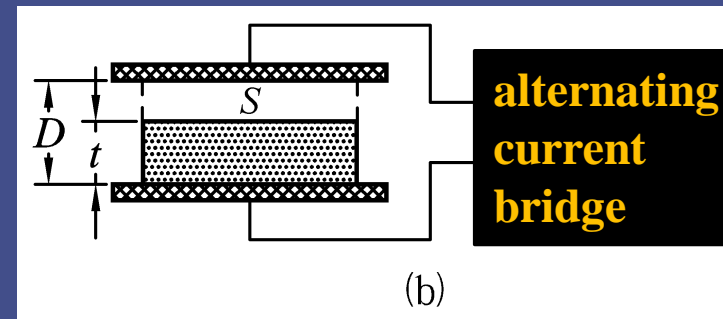
1、 Measure the dielectric constant of solid dielectrics by alternating current bridge

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:

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

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

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

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

$$C_C = C_2 - C_1 + C_0$$

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

2、 Calculations of 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:

$$C = \frac{\epsilon_0 S_0}{D} + C_F$$

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

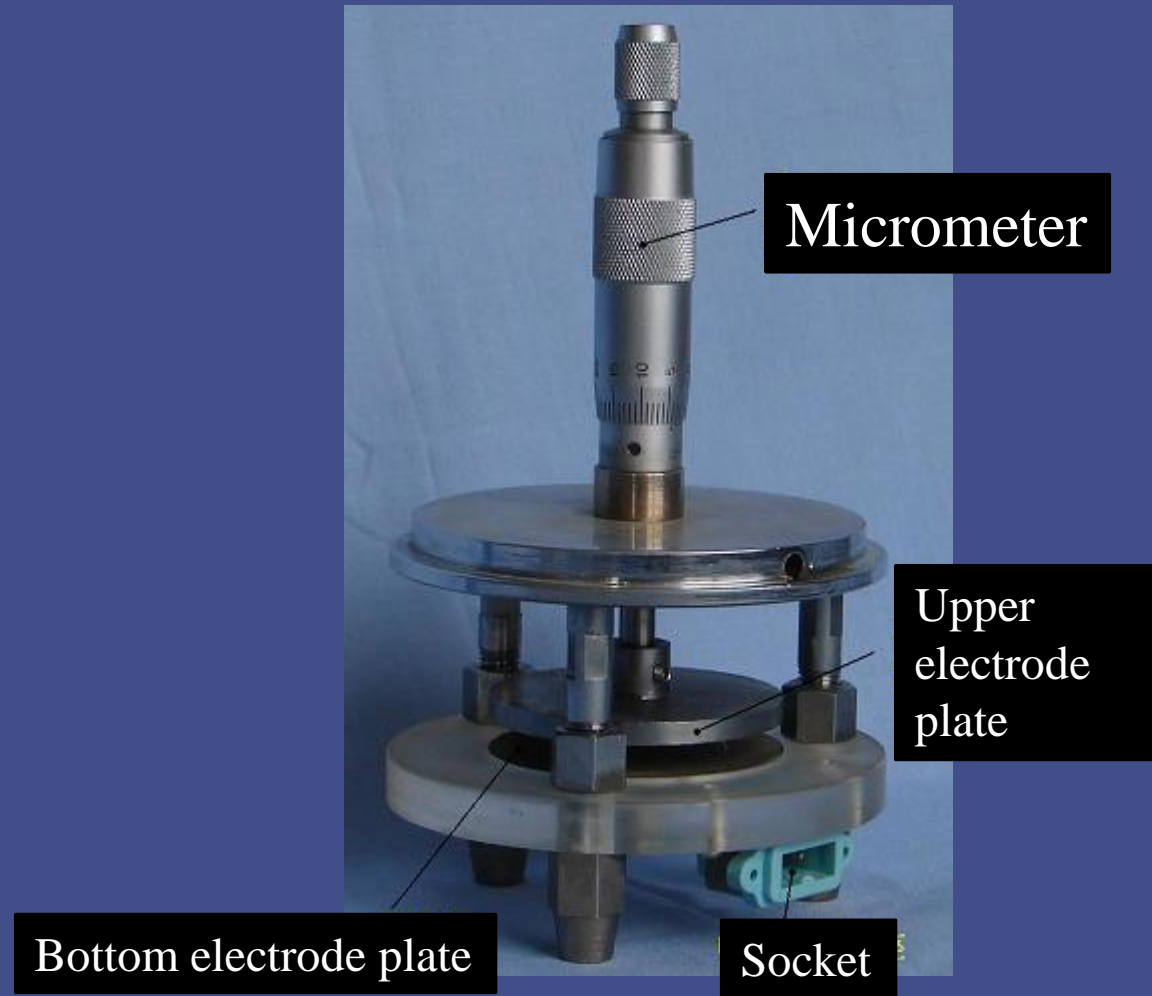
$$y = a + bx$$

We got $a = C_F$, $b = \epsilon_0 S_0$

Finally, we have $\epsilon_0 = b/S_0$

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 D_0 .
- (c). Set the distance of the plates as 5.000mm. Note that the real value in micrometer should be $5.000\text{mm} + D_0$. 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 .

$$C = \frac{\epsilon_0 S_0}{D} + C_F$$

Set $x = 1/D$, $y = C$

Calculate C_F and ϵ_0 using origin software.

Data processing:

Table I

Starting value $D_0 = \underline{0.000}$ mm, Distance $D = \underline{5.000}$ mm
 $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$

	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	44.18	3.95	$\pi(d/2)^2 =$	2.70	18.90	21.73		
2		44.18	3.92			19.00	21.77		
3		44.17	3.94			19.10	21.75		
Average									

d: diameter of sample,

t: thickness of sample,

$$S = \pi(d/2)^2$$

$$C_0 = \frac{\epsilon_0 S}{D}$$

$$C_C = C_2 - C_1 + C_0$$

$$\epsilon_r = \frac{C_C \cdot t}{\epsilon_0 S - C_C (D - t)}$$

$$1 \text{ F} = 10^{12} \text{ pF,}$$

$$1 \text{ m} = 10^3 \text{ mm}$$

Table II

D/mm	1.000	1.100	1.200	1.300	1.400	1.500	1.600	1.700	1.800	1.900
$1/D(\text{mm}^{-1})$										
C/pF	29.75	28.22	26.93	25.95	25.25	24.42	23.44	22.83	22.39	21.78

$$C = \frac{\epsilon_0 S_0}{D} + C_F$$

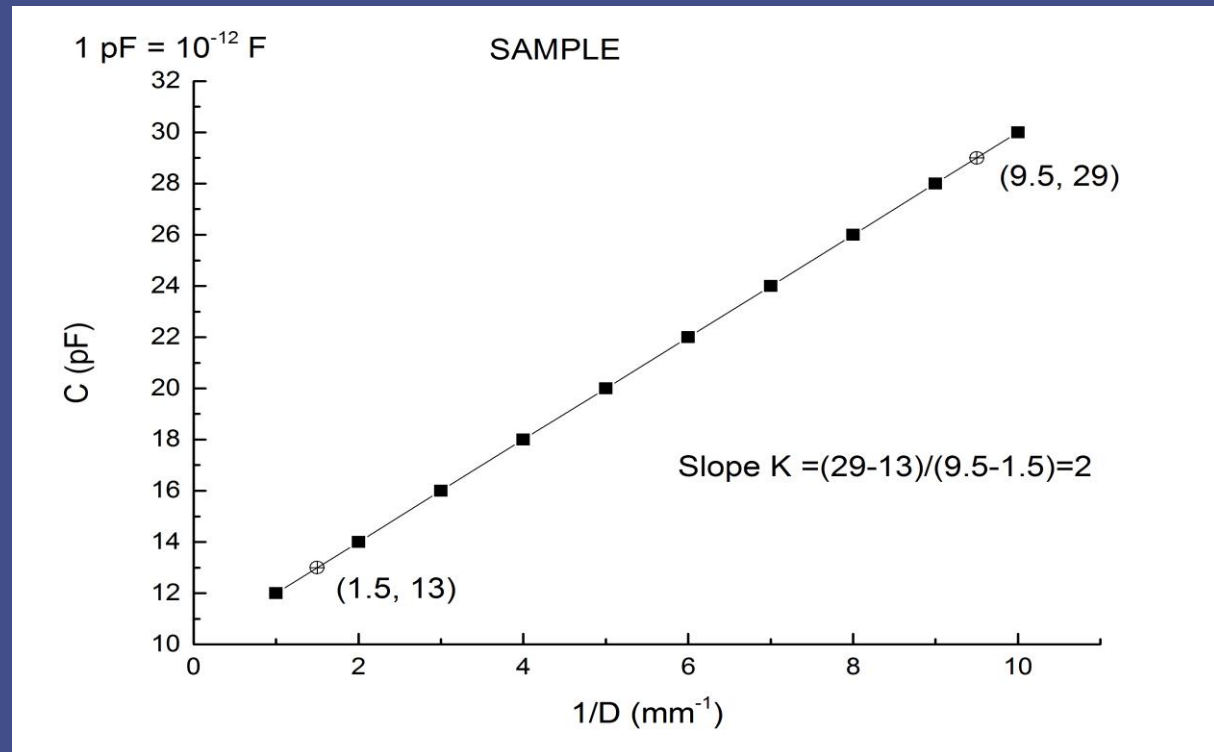
Set $x = 1/D$, $y = C$,
calculate ϵ_0 .

The Slope $K = \epsilon_0 S_0$,

$\epsilon_0 = K / S_0$

The Intercept is C_F .

Note: $S_0 = 21.61 \text{ cm}^2$.



Here is the weblink to download this slide:

<https://github.com/bliseu/phylab/blob/master/Dielectric%20constant%20measurement.pdf>

1. Please finish the table I and II in the slide.
2. Plot a $1/D$ - C line, determine the slope ($K = \epsilon_0 S_0$) and intercept (C_F) of the line, then calculate ϵ_0 and compare it with the theoretical value ($\epsilon_0 = 8.85 \times 10^{-12} \text{F/m}$).
3. Write a 500-word essay to describe the “Dielectric constant”.

The DEADLINE is June 8, 2022.

END