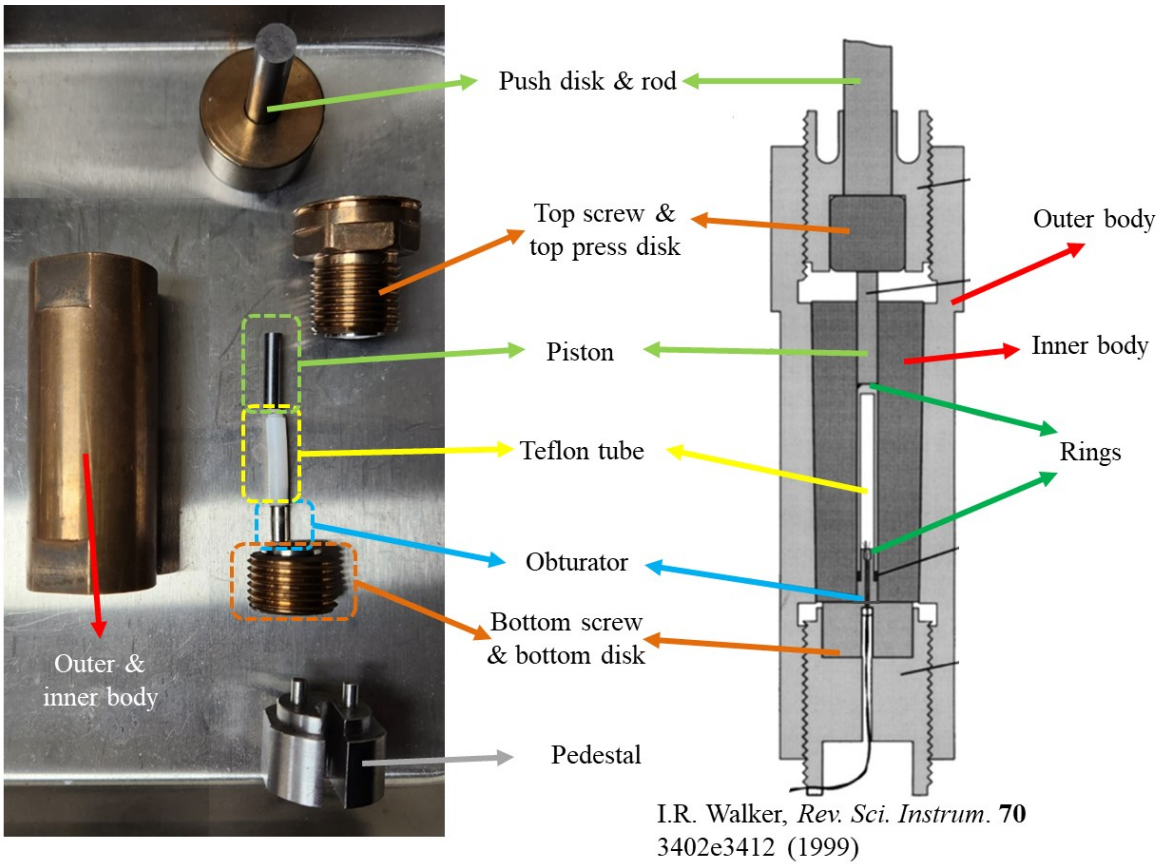
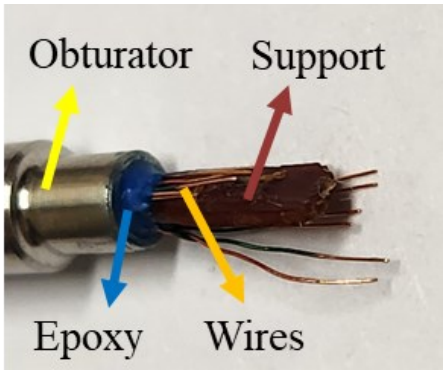
Piston-Cylinder Pressure Cell Manual & van der Pauw method

ver. 1.0 2024.05. Sangjin Kim

A. Piston-Cylinder Pressure Cell manual



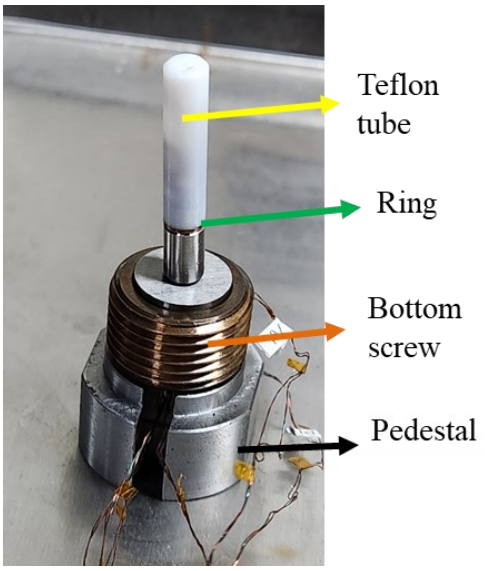
1. Insert the required number of coated wires into the obturator.
2. Fill the interior of the obturator with Stycast epoxy and insert the Bakelite support (if necessary) parallelly. (Be careful not to let the epoxy touch the surface of the obturator. The width of the support should not exceed the inner radius of the obturator.)
3. Let the epoxy cure for more than 24 hours at room temperature. (Keep the Bakelite support parallel to the obturator during curing.)

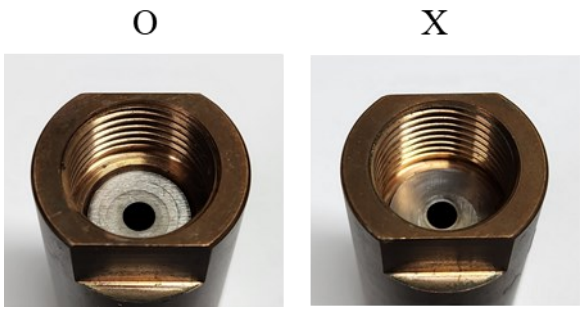


4. Attach the sample (including a manometer/thermometer if necessary) to the Bakelite support and make electric contacts with the wires.

5. Fill the Teflon tube with pressure medium and couple it with the Obturator by placing a ring in between. (Ensure that the larger radius of the ring touches the Teflon tube.)

6. Pass the wires of the obturator through the hole of the bottom screw. And connect the bottom screw to the outer body while fitting the Teflon tube to the inner body. (Insert the Teflon tube to the side where the inner body protrudes less.) Then, use the pedestal to fully tighten the bottom screw.



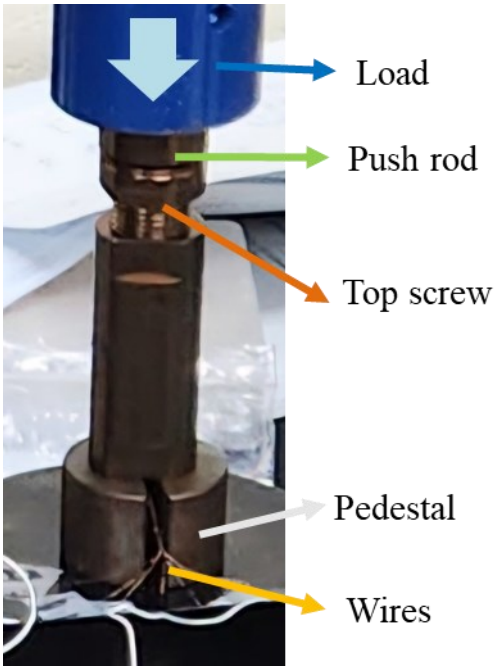


7. On the opposite side of the inner body, insert the side of the ring with the larger radius towards the teflon tube, and place the piston on top of it

8. Before connecting the top screw and top press disk to the outer body, apply lubricant to the area where the top press disk meets the piston. This prevents friction welding between metals of the same type.

9. Similarly, couple the push disk and rod to the top press disk by applying lubricant to the area where they meet.

10. Carefully apply small load onto the push rod and fully tighten the top screw. (When applying pressure, support the body with the pedestal to ensure that the load is not directly applied to the wires.)



11. Maintain the appropriate pressurization rate ($\Delta P_{\text{sample space}}/\Delta t$ < 5 GPa/h) while pressurizing. Before the push rod contacts the top screw, use a spanner to tighten the top screw. Repeat this process while pressurizing.

12. Once the desired pressure is reached, fully tighten the top screw and wait for a sufficient time. Then, slowly depressurize the load pressure to atmospheric pressure. Remove the push disk and rod. Wait for a sufficient time until the pressure inside the sample space stabilizes.

13. Proceed the electrical measurements on the sample in a desired environment.

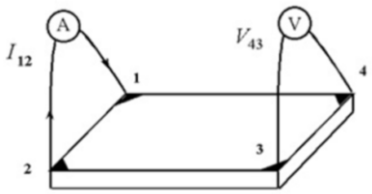
14. After the measurements are complete, connect a push disk and rod of sufficient length above the top screw and apply load to offset the pressure trapped in the sample space. Slowly depressurize while releasing the top screw, and then use the pedestal to release the bottom screw. Insert the removal rod into the inner body and apply pressure to remove the piston and obturator.

B. The van der Pauw method inside the PPMS cell

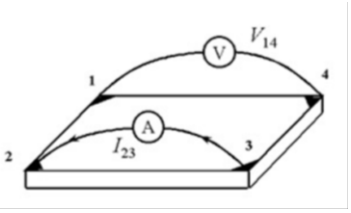
Examples of ideal van der Pauw contacts.

1. To obtain bulk resistivity ρ of the sample, measure $R_{vertical}$ and $R_{horizontal}$.

$R_{vertical} = (R_{12,34}+R_{34,12}+R_{21,43}+R_{43,21})/4$ and $R_{horizontal} = (R_{23,41}+R_{41,23}+R_{32,14}+R_{14,32})/4$.



$R_{12,34}=V_{34}/I_{12}$

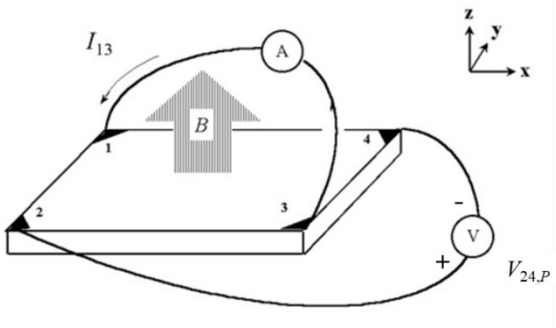


$R_{23,41}=V_{14}/I_{23}$

By applying $R_{vertical}$ and $R_{horizontal}$ to the following expression, sheet resistance R_S can be obtained.

$\exp(-\pi R_{horizontal}/R_s) + \exp(-\pi R_{vertical}/R_s) = 1.$

Bulk resistivity is $\rho = R_S \times d$. (d is the thickness of the sample)



2. To obtain Hall voltage V_H of the sample, following voltage data should be measured.

$V_{13}=V_{13,P}-V_{13,N}$

$V_{24}=V_{24,P}-V_{24,N}$

$V_{31}=V_{31,P}-V_{31,N}$

$V_{42}=V_{42,P}-V_{42,N}$

$V_{,P}$ is for $\hat{B} = +\hat{z}$ and $V_{,N}$ is for $\hat{B} = -\hat{z}$ cases.

Let the amount of current in each run be identical.

Then, Hall voltage V_H is as follow.

$V_H = (V_{13}+V_{24}+V_{31}+V_{42})/8$