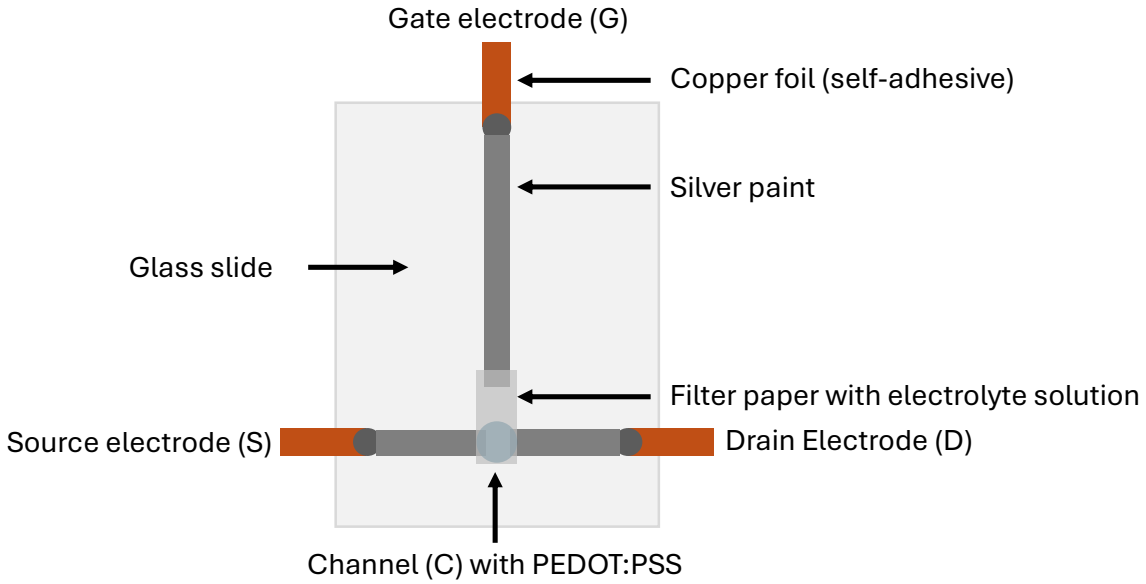
Experiment: Construction of an Organic Electrochemical Transistor (OECT)

Safety measures: Safety glasses, lab coat, well-ventilated room

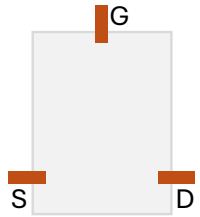
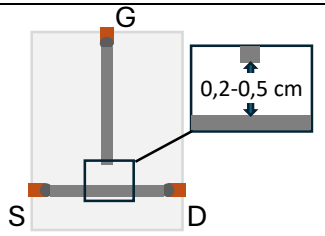
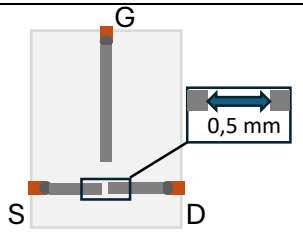
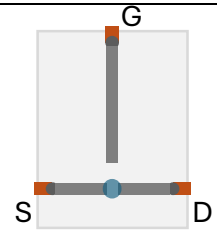
Materials per group:
Semiconductor-solution (PEDOT:PSS, 2-propanole, ethylene glycol), potassium chloride solution (1 M), 2x glass slides (ca. 3,5 x 2,5 cm), 3x copper foils 0,5 cm (self-adhesive), silver-paint (incl. brush), needle/ pin, glass stirring rod, cotton swab, filter paper, scissor, 2x foldback clips, power-supply, 1.5 V AA battery with case, 5x alligator-clip cable

Materials centrally available:
tweezers, hotplate

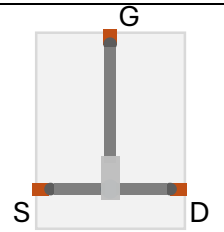
Marking of components of the OECT



Instruction manual: building an OECT

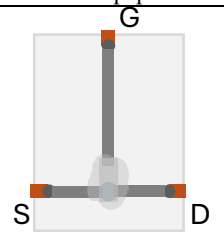
1. Attach the copper contacts as shown in the figure on the right with the adhesive side to one of the two glass substrates. Note: The copper foil has a protective film on the back, which must be removed. Fold the protruding ends of the copper foils over to the back of the glass substrate.	 Copper contacts
2. Shake the bottle of silver conductive paint well. Then, use a brush to apply a narrow conductive trace between the **Source (S)** and **Drain (D)** copper contacts. Next, apply a vertical conductive trace (= **Gate electrode**) downward from the **Gate (G)** contact. The distance between the end of the Gate electrode and the S-D trace should be approximately **0.2–0.5 cm** (see enlarged detail in the image).	 Conductive traces
3. Place the device on the hotplate at **110 °C for 3 minutes** to evaporate the solvent. Afterwards, use tweezers to remove the device from the hotplate and let it cool in air for **30 seconds**. Then, use a sharp and clean object (e.g., a pin) to scratch a small gap (**Channel**) in the middle of the S-D trace. The gap size should be approximately **0.5 mm** (see enlarged detail in the image).	 Channel
4. Dip a clean glass stirring rod lightly into the **PEDOT:PSS suspension** to wet its tip. Gently press the PEDOT:PSS-coated end onto the **Source-Drain gap (Channel)** to deposit the suspension (see image on the right). Then, place the device on the hotplate at **110 °C for 5 minutes** to cure the PEDOT:PSS (= **annealing**). *(Use this time to proceed with **Step 5**.)* Afterwards, remove the device with tweezers and let it cool in air for **30 seconds**. If necessary, remove excess PEDOT:PSS with a damp cotton swab.	 PEDOT:PSS

5. Cut a small piece of filter paper to serve as the carrier for the electrolyte solution. The dimensions should be such that the filter paper fully covers the **PEDOT:PSS Channel** and extends a few millimetres over the **Gate electrode** (see image on the right).



Filter paper

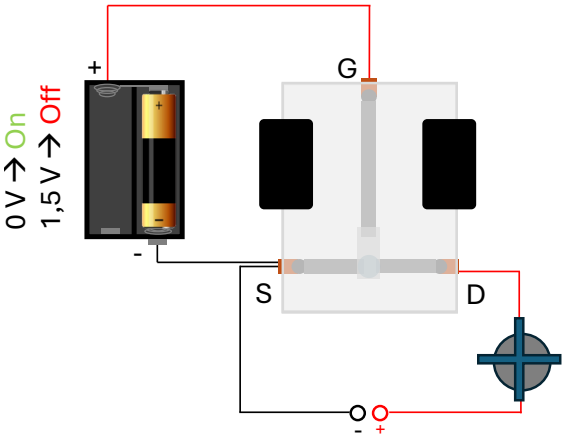
6. Dip the piece of filter paper into the **1 M KCl solution** using a tweezer and place the filter paper as a connecting bridge between the **Gate electrode** and the **Channel** on the substrate (see image on the right). Then, place the second glass slide precisely over the device and secure it with **two foldback clips** to encapsulate the device (see image in **Step 7**).



Electrolyte (KCl)

7. In the final step, connect the device to the **power supply**, **propeller**, and **battery** as shown in the image on the right.

- First, connect the **Source (S)** of the OECT to the **negative (–) terminal** of the power supply using an alligator clip cable.
- Next, use another alligator clip to connect the **positive (+) terminal** of the power supply to the **motor**.
- Then, connect the motor's other terminal to the **Drain (D)** contact of the OECT using another alligator clip.
- Now, connect the **Source (S)** contact of the OECT to the **negative (–) terminal** of the battery.
- When you turn on the power supply at **+0.6 V**, the propeller should start spinning because **PEDOT:PSS is naturally in the ON-state (conductive)**.
- Finally, connect the **positive (+) terminal** of the battery to the **Gate (G)** contact of the OECT. This **dedopes the PEDOT:PSS**, making it insulating and switching the OECT to the **OFF-state**.
  - The propeller should stop spinning after a short delay.
  - When you **disconnect the Gate contact**, the OECT returns to the **ON-state**, and the propeller should start spinning again (this may take a few seconds).
  - You can switch between **ON/OFF states** repeatedly as desired.



Construction of the electric circuit to test the OECT