Functional Materials
FM6 - Solid ionic and mixed Conducters:
Memory Element

Klaudia Herbst   Sven Marten Czerwonka
Manfred Thomann

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1 Theory

An electrochemical cell consist basically of contacts, electrodes and an electrolyte. In this case the contacts are Pt leads, one electrode consist of Ag and the other consist of Ag_2Se and finally the solid electrolyte is $Ag_5I_4WO_4$. The solid electrolyte in this case has a high ionic conductivity for silver ions and also the conductivity for electrons is very low.

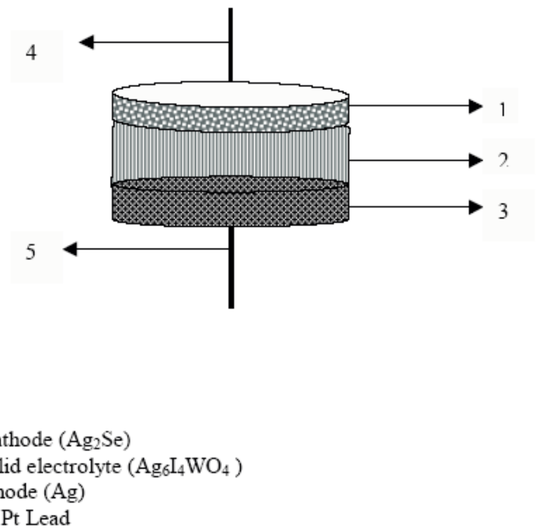

Abbildung 1: Schematic diagram of an electrochemical potential memory cell

2 Measuremeant

This cell is capable to be recharged and to hold the charge for a long time. In this experiment we will measure the voltage of the cell after charging and after discharging with a given current. The results of the measuremeant are shown in table 1 and table 2.

2.1 Resistance of the memory cell

The resistance of the memory cell can be determined with the given current and measured voltage. The average resistance is 5,55 MΩ, the single values are shown in fig. 5.

Current $[\mu A]$	Voltage U_{charge}[mV]	Error U_{charge}[mV]	Voltage $U_{discharge}$[mV]	Error $U_{discharge}$[mV]
0,05	270	±10	-280	±10
0,1	580	±10	-550	±20
0,15	850	±10	-810	±10
0,2	1130	±10	-1120	±10
0,25	1420	±10	-1410	±10
0,3	1700	±10	-1640	±10
0,35	1990	±10	-1890	±10
0,4	2290	±10	-2170	±10
0,45	2540	±10	-2410	±10
0,5	2810	±10	-2650	±10

Tabelle 1: measuremeant for 1 min charging and discharging

Current $[\mu A]$	Voltage U_{charge}[mV]	Error U_{charge}[mV]	Voltage $U_{discharge}$[mV]	Error $U_{discharge}$[mV]
0,05	290	±10	-260	±10
0,1	590	±10	-535	±10
0,15	865	±10	-820	±10
0,2	1150	±10	-1070	±10
0,25	1405	±10	-1330	±10
0,3	1705	±10	-1590	±10

Tabelle 2: measuremeant for 2 min charging and discharging

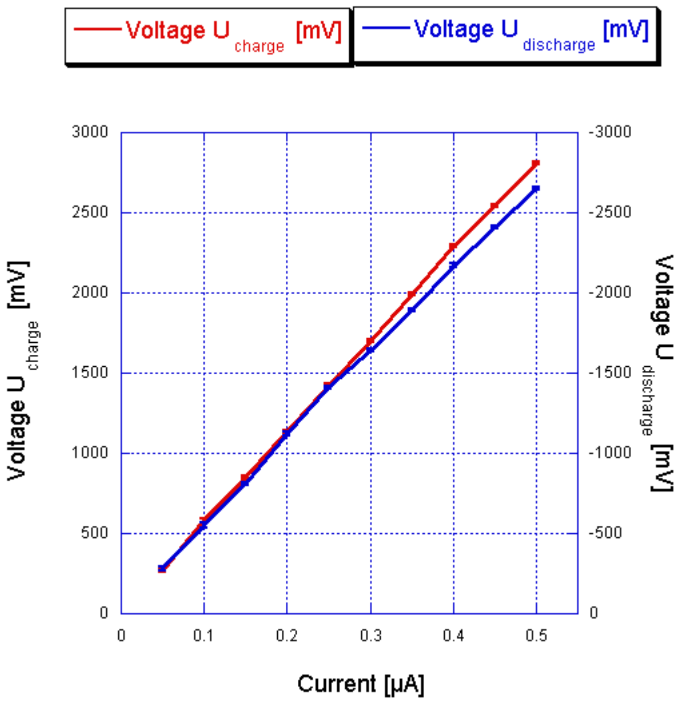

Abbildung 2: measuremeant for 1 min charging and discharging

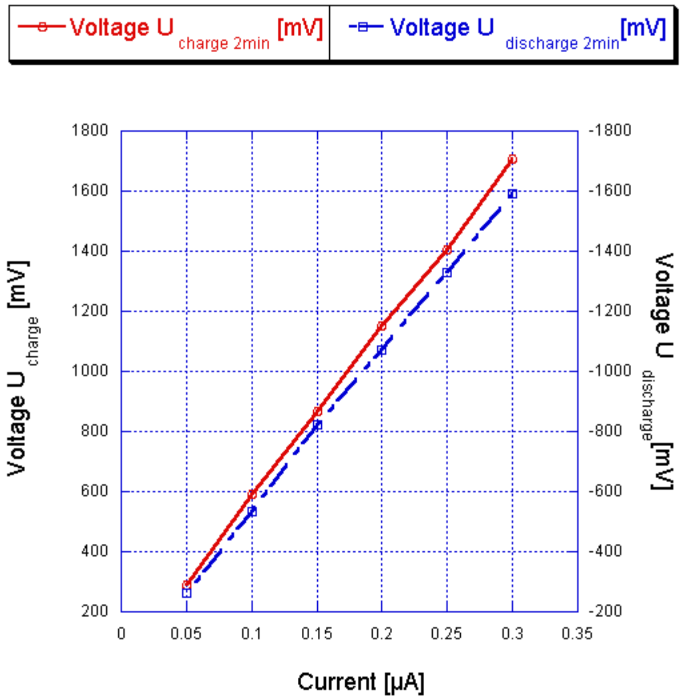

Abbildung 3: measuremeant for 2 min chraging and discharging

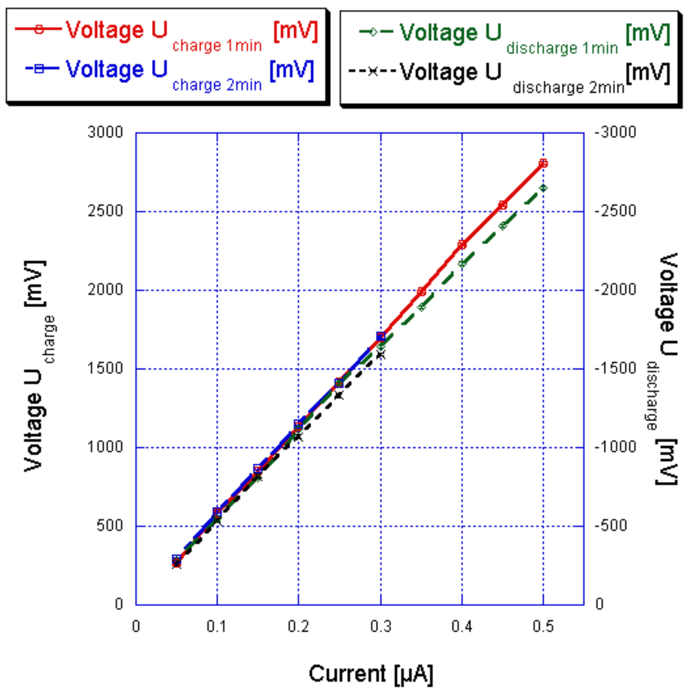

Abbildung 4: combination of the measurements

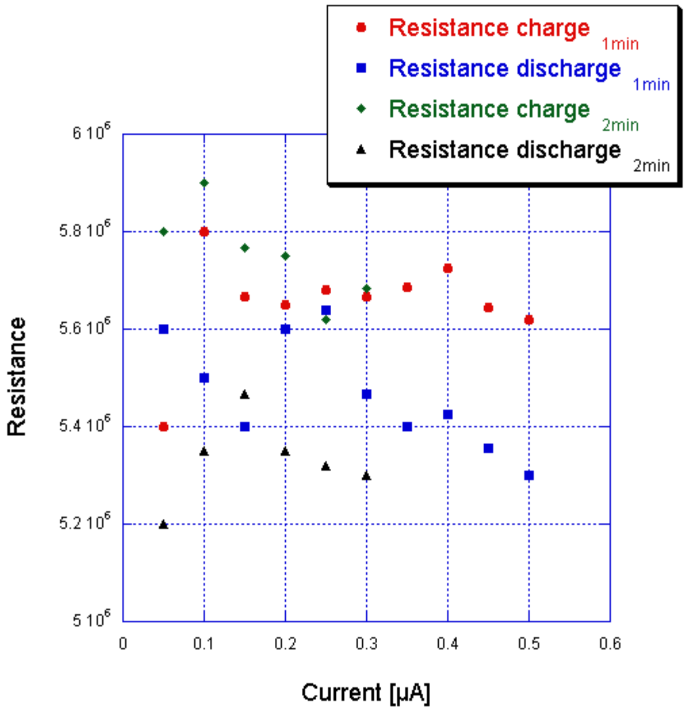

Abbildung 5: Values for determination of the cell's resistance

3 Questions

1. **What are ionic and electronic conducters?**
   Ionic and electronic conducters transport charge by electrons and or ions. Electronic conducters are metalls, ionic conducters are e.g. ionic crystals.

2. **Distinguish between ionic and electronic conducters?**
   In metalls the charge transport is given by the electron gas. The conductivity of the free electrons gas is much higher than the conductivity of ions. The charge transport by ions in a perfect ionic crystal is almost zero, but may be extremly raised by natural and/or inserted vacancies. This effect is analog to doping a semiconductor.

3. **What is a mixed conductor? Give some type of mixed conductor. Explain their advantages over other two type of conductor.**
   A mixed conductor transports charge by electrons and ions. Types of mixed conducters are metal oxides and composites with ionic and electronic phase. A mixed conductor has more possible applications e.g. in solid oxid fuel cells.

4. **How do you measure ionic and electronic conductivity of materials?**
   Conductivity can be measured by a.c. impedance method e.g. in a kiel cell. With this method conductivity as function of temperature and frequency can be measured. For ionic conductors the resistance should be in the easiest case proportional to $e^{\frac{1}{T}}$. Because of the much higher electronic conductivity in a mixed conductor, the cell has to be modified to measure the ionic conductivity. In this case a phase with higher ionic conductivity and no electronic conductivity has to inserted to supress the electronic charge transport. Another possibility is to measure only the ionic material, this is possible for mixed conducters that consist of 2 phases.