DEVELOPMENT OF THIN-LAYERED GAS SENSORS FOR BATTERY CELL MONITORING

Svitlana Krüger[1], Bilge Saruhan[1]
[1] *Institute of Materials Research, German Aerospace Center (DLR), Linder Hoehe 51147, Cologne, Germany*

Formation of gaseous side products caused on cell degradation in LIBs has been significantly responsible for the performance decay and safety issues and thus, has been intensively studied in recent years [1,2]. The degradation leading to gas generation during battery operation is related to the side reactions between electrode material and electrolyte and thus, strongly dependent on the type of anode, cathode and electrolyte used to manufacture the battery [1]. According to the experimental studies CO and CO_2 gases are released on cathode side during the cycling of lithium-ion batteries, while C_2H_2, CO and H_2 gases production occurs on anode side [3]. In general, four main sources for the release of gaseous substances inside the electrochemical cell can be distinguished: (1) CO and CO_2 evolution due to the oxidation of the organic electrolyte; (2) CO and O_2 formation as a result of electrochemical decomposition of residual carbonate species (particularly in the case of Ni-rich NMC cathode powders in the initial charge cycle); (3) O_2 release due to the structural instability of NMC cathode at high states of charge; (4) H_2 formation due to reduction of residual moisture in the cell and electrochemical decomposition of the carbonate electrolyte [2,3].

The investigations of the present work are done in the frame of PHOENIX project (Horizon Europe under the grant agreement No. 101103702) aiming to develop initially highly sensitive thin-layered metal oxide-based sensors for hydrogen detection and for integration inside the battery cell. For this purpose, sensors consisting of top-bottom electrode (TBE) configuration and a Cr-doped TiO_2 sensing layer were fabricated in three steps: (1) deposition of bottom Pt electrodes on flexible PI film substrate via sputter coater (BALTEC, Hallbergmoos, Germany); (2) sputtering of Cr-TiO_2 sensing layer using Z400 magnetron-sputtering equipment (SVS, Gilching, Germany); (3) deposition of top Pt electrodes as cross-bar batter to the bottom Pt electrodes (Fig.1a). Gas sensing tests were performed with the sensor and catalyst characterization unit SESAM, which contains 8-channel flow controller from MKS Instruments GmbH, a Quartz inlay gas mixing and heating chamber in CARBOLITE tube furnace, and Keithley 2635A Source meter DC-measurement unit. All setup instruments were controlled with LabVIEW program. Gas sensing measurements were performed towards different H_2 concentration (600-1000 ppm) at different temperature (RT, 40°C, 60°C) with a constant 1 V bias. Almost no response was seen at room temperature in all range of H_2 concentration, while the increase of working temperature to 40°C led to a good sensor response towards the lowest measured H_2 concentration of 600 ppm (Fig. 1b).

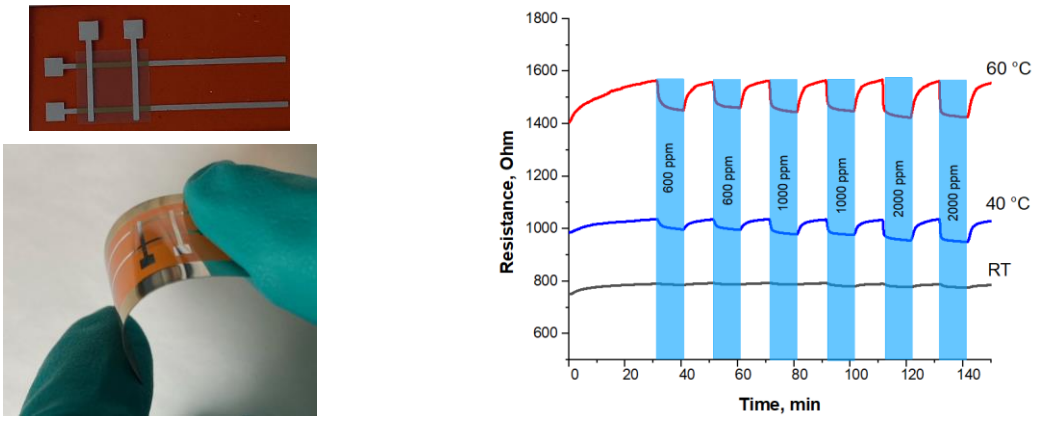

Figure 1. (a) TBE sensor on flexible PI film substrate; (b) Dynamic sensor responses towards different H_2 concentrations at different temperatures.

REFERENCES

[1] Adv. Funct. Mater. 2022, 32, 2208586
[2] ACS Appl. Mater. Interfaces 2020, 12, 20462-20468
[3] Journal of The Electrochemical Society, 2019, 166 (6) A897-A908