**Final report of the AKTION 77p2 project**

**for the period from 1st January 2017 to 31st December 2017**

**Basic information**

**Start date**: 15th October 2016

**End date:** 31st December 2017

**Project partners:** TU Wien – principal investigator – Prof. Günter Fafilek

BUT – principal investigator – Doc. Ing. Marie Sedlaříková, CSc.

**Stays of TU Wien employees at DEET BUT FEEC**

**Günter Fafilek, Dr.A.o. Univ. Prof.**

Dates: November 27th to November 28th, 2017 – 1 night, 2 days

Programme of the visit at BUT:

a) Summarizing of project results for the final report

b) Evaluation of results preparation of material samples and their measured properties

c) Preparation of a joint publication for a reputable journal

d) Agreement on preparation of thin layer systems based on Al2O3

e) Discussion about further cooperation, for example extension of the ACTION project

**Bc. Fabian Born**

**Bc. Patrik Gugenberger**

Dates: November 27th – December 6th, 2017 – 9 nights, 10 days

One of the TU Wien students measured viscosity and conductivity of electrolytes with dissolved MG salts for use in Mg-Ion batteries. The other student used the SEM at BUT for studying morphology and composition of prepared electrode materials (prepared at TU Wien) based on Li3V2(PO4)3. Test electrodes with these materials were then prepared. Measurement of conductivity by means of 4point method was carried out for some of the samples.

**Stays of DEET FEEC BUT employees at TU Wien**

**Doc. Ing. Marie Sedlaříková, CSc; Ing. Miroslav Zatloukal**

Dates: March 14th to 15th, 2017, November 13th to 14th, 2017

Preparation of the research stay for Ing. Jiří Tichý at TU Wien. Other possibilities of thin layers (suitable as electrolytes in battery systems with NA ions) preparation were discussed. Wafers of intrinsic or high resistance silicon will be obtained for magnetron reactive sputtering of oxide layers. Si substrate will be obtained directly from a manufacturer. The quality of layers will be assessed by a SEM. Subsequently, tests of intercalation abilities of Na into these layers will be prepared.

It was agreed upon preparation of a publication which will be published in ECS Transaction in 2017.

Preliminary evaluation of cooperation in new systems research was carried out and, based on consultation at TU Wien, it was agreed on further cooperation. Details will be arranged at the beginning of 2018.

**Ing. Jiří Tichý**

Dates: 14th September 2017 to 14th October 2017

Measurements of current passing through a system with a capillary were done.

Measurements were done in a system consisting of a glass flask filled with 0,1N H2SO4 + 0,01 M CUSO4, copper counterelectrode and a working electrode which was a copper wire in a capillary filled with 1N H2SO4. The system was bubbled with nitrogen in the tight glass flask.

There was the voltage of 0.3V between the working electrode and counterelectrode and current was measured. Values of current were in the range from 10-5 to 10-7 A. The distance of the copper wire inside the capillary from the opening of the capillary was gradually changed from 0.5cm to 3.0cm. The measurement was done for two sizes of the capillary – volume of 20 μl and 10 μl.

Another system was then measured, in which the electrodes were made of platinum wire. Electrolyte was 1N HCl + 0,001 FECl3. HCl was used inside the capillary with the working electrode. A variant with 1N HCl was also measured for validation. The rest of the parameters was the same as in the previous system.

It is possible to calculate the diffusion coefficient from the measured currents and to use these measurements when evaluating other, planned measurements. These measurements should be done inside a glove box with argon atmosphere, without nitrogen bubbling. Electrolyte will be the same as is used in Li-ion batteries or ionic liquids. It will then be possible to evaluate the suitability of these electrolytes/ionic liquids for use in Li-ion batteries.

**Summary of achieved project results:**

Si wafers with low conductivity were obtained (intrinsic Si is not available) and, using a verified method (content of O2 in the working space), the Al2O3 layers on the wafer surface will be modified with the aim to increase ion conductivity. It was found out that additional oxidation takes place outside the working space after reaction sputtering of Al. Observation of the surface by SEM showed that even the layer coated in argon atmosphere is not long-term stable during electrochemical tests and it is being damaged. It will be necessary to modify layers preparation methods to eliminate these defects or, after consultations, to modify test and control processes.

It can be assumed that cooperation between universities concerning transportation of ions in materials for battery masses, aimed on substitution of lithium (Li) by sodium (Na), will continue.

Joint publication:

KAZDA, T.; ČUDEK, P.; VONDRÁK, J.; SEDLAŘÍKOVÁ, M.; TICHÝ, J.; SLÁVIK, M.; FAFILEK, G.; ČECH, O. Lithium- sulphur batteries based on biological 3D structures. *Journal of Solid State Electrochemistry,*2017, No. 1, p. 1-7. ISSN: 1432-8488.

**Final summary of the results:**

1. All points in an approved programme were fulfilled.
2. Results of ion liquids conductivity measurements (detailed results available from researchers) show that it is possible to use them in electrochemical energy sources. It is necessary to check other new systems modifications, including additives modifying ion conductivity (Li and Na salts were tested), safety on new battery systems and their influence on electrode masses. Finally, their stability and durability during charging and discharging must be checked on the best specimen with special attention on NA conductivity additives.
3. Research of properties of thin layers based on Al2O3 is a new option how to use their unique conductive properties. It is recommended to continue the research by preparing the technology of their preparation (magnetron sputtering) in different modes and in different working environments. That means higher number of prepared layers, their compatibility with electrode materials, behavior changes during cycling. Using high resistance Si substrates and their influence on the structure and resulting oxide layers properties is of a special importance.

These results of joint research of the two universities are promising and the successful cooperation between doctoral and masters students is also beneficial.

These are the reasons why to think about **continuation of the long-term successful cooperation between the two universities.**