Project: **SEAWave**

In vitro exposure system acceptance test

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Abstract

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1 Introduction

To conduct the foreseen in vitro experiments in human-derived skin cells, as outlined in WP8 of the SEAWave project, ZMT has designed and constructed a 5G exposure system based on dose considerations and calculations that have been performed by IT'IS in WP2 beforehand.

The system for blinded electromagnetic field exposure of cell cultures in cell culture flasks had to be integrated into a cell incubator, being big enough to harbor three shielded far field chambers for 5G FR2 signals at 27.5 GHz, including an automatic control system with exposure and temperature monitoring and data logging. The three exposure chambers are allocated by chance and in a blinded way to high power density, low power density, and no (sham) exposure, without knowledge of Fraunhofer ITEM, who performs the respective cell experiments, about the actual assignment of the three chambers to exposure modes. Signals are 5G FR2 100 MHz bandwidth and an operation frequency of 27.5 GHz. the high-power chamber will support 3x higher field strengths than the low-power chamber (20W/m² and 6.67 W/m²).

2 In vitro exposure setup: Reception

Initially scheduled for July 2023, the In-vitro Exposure System was delivered on March 22, 2024, to Fraunhofer ITEM, Hannover, Germany. Dr. M. Capstick and his colleague I. A. Marin from IT'IS Foundation visited Fraunhofer ITEM on March 25 to 26, 2024, for assembly of the entire setup of the exposure system with integration into an appropriately big cell incubator with large cable channel, and performed initial acceptance checks together with the Fraunhofer ITEM coworkers. The general exposure set-up was finalized by end of these two days.

The in vitro exposure system for the SEAWave cell experiments comprises a signal generator, an R&S SMCV100B multi-standard platform for broadcast, navigation, cellular and wireless applications. The system is controlled using a computer over an Ethernet link, which enables the blinding of the experiment and controls both temperatures and the exposure level in each of the three exposure chambers. Continuous monitoring of environmental parameters (such as temperature, electric fields, and power) will be performed.

3 In vitro exposure setup: Acceptance Tests

The chambers had originally been fabricated by ZMT but were then characterized by the IT'IS Foundation to ensure that the delivery by ZMT meets the requirements. Most of the characterization had been done prior to the installation at ITEM.

Further verification was then performed on-site at ITEM in cooperation between IT'IS and ITEM:

- The first trial, conducted after assembly, involved switching on the exposure setup with no cell culture flasks in the incubator and the incubator still switched off. This was considered as an initial test to verify the functionality and appropriate interaction of all devices, the control unit, and the monitoring sensors. The field homogeneity was measured using DASY8 and a mm-wave probe, with calibration traceable back to national standards, over the exposure plane of the cultured cells.
- The second test was performed similar to the first trial, with the difference in experiment duration of 24 h and blinded experiment.

The test passed successfully in a run of 2 and 24 hours.

- The third test was conducted with cell culture flasks filled with medium and the incubator switched on for 24 h in a blinded experiment. This test aimed to verify whether nominal power levels and electric field levels could be achieved in loaded conditions, to check the influence of cell culture medium and flask materials on the electromagnetic field and to confirm if the CO_2 was circulated into the chambers as a requirement of proper cell culture.

For above-mentioned aims, the test passed successfully. However, a minimal temperature exceedance of ≤ 0.4°C in chamber number 1 was observed. Another 12-h blinded test was performed to verify this observation. The temperature increase was indeed observed in the chamber number 1. Further decoding presented that chamber 1 was sham exposed in the latter test, which showed the temperature increase was not caused by the electromagnetic field. This temperature difference could be corrected via remote access by Dr. M. Capstick, IT'IS. Further 24- and 72-h test runs showed that the temperature difference was corrected successfully.

During these tests ITEM coworkers got familiar with the exposure system and received some training on switching the in vitro exposure setup on and off and using the control software to manage the setup.

The acceptance tests performed were successful.

4 Conclusion

The in vitro exposure setup for the SEAWave experiments was successfully installed in a cell incubator at Fraunhofer ITEM's cell culture unit and tested for its operability for planned short term exposures (up to 24 h) of human-derived skin cells in vitro within the SEAWave project. The performed tests demonstrated that the system works properly and reliably.