



FIZINIŲ IR
TECHNOLOGIJOS MOKSLŲ
CENTRAS

Project G6002 “3D Metamaterials for Energy Harvesting and Electromagnetic Sensing” Kick-Off Meeting

The NATO Science for Peace and Security Programme

Žilvinas Kancleris
NATO Country Project Director
Center for Physical Sciences and Technology

7 June, 2023



*This project
is supported by:*

The NATO Science for Peace
and Security Programme

The outline

- 1. The task of the project.**
- 2. Input of participants.**
- 3. Brief overview of work packages.**
- 4. First six months deliverables and milestone.**
- 5. Conclusions.**

Task of the project

The project will focus on the development of energy-efficient, reliable, and compact microwave rectennas and electromagnetic field sensors that will be used for energy harvesting for IoT devices, different types of sensors, and RFID systems, as well as for electromagnetic sensing.

Participating institutions

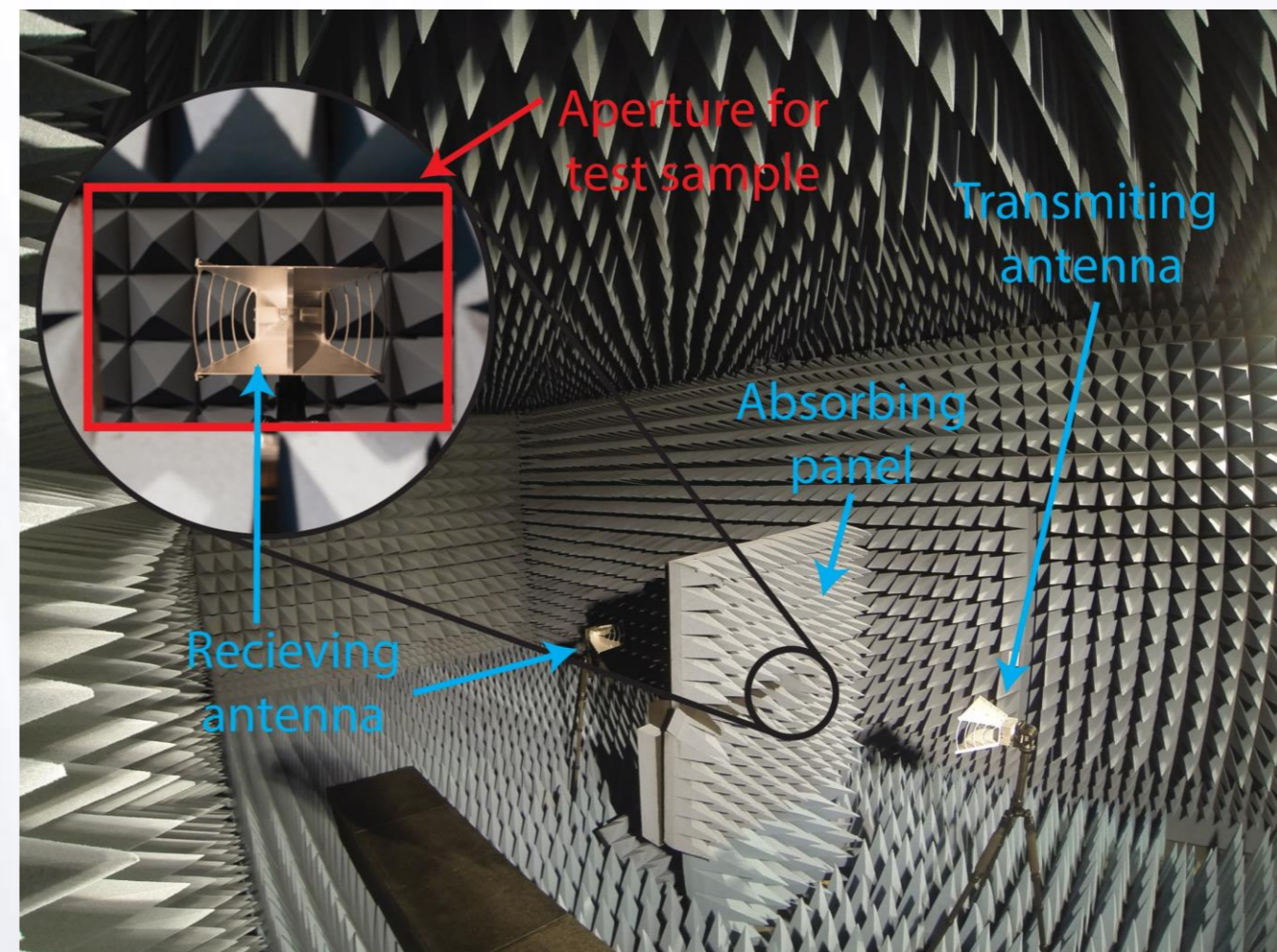
- **Center for Physical Science and Technology (FTMC), Vilnius, Lithuania, NPD, Dr. Žilvinas Kancleris.**
- **Igor Sikorsky Kyiv Polytechnic Institute (KPI), Kyiv, Ukraine, PPD, Dr. Mykhailo Ilchenko.**
- **V. I. Vernadsky Institute of General and Inorganic Chemistry, NAS of Ukraine (IGIC), Co-Director, Dr. Anatolii Belous.**

Tasks in the project

Simulations of microwave antenna, rectifier circuit design, manufacturing and testing of rectennas, and metal deposition on dielectric materials using SSAIL technology.

Available equipment

- Anechoic chamber 1-20 GHz
- HPM pulse power sources at fixed freq. at S, C, X, Ku, Ka and W bands.
- Tunable TWTs, up to 2 kW pulse power.
- Low power tunable generator up to 20 GHz.
- Corresponding waveguide sensors for HPM pulse power measurement.
- Radiating and receiving antennas, measurement equipment



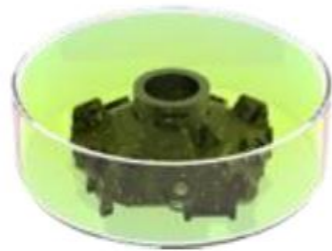
$l=8.4$ m, $w=4.6$ m, $h=3.7$ m

Selective Surface Activation Induced by Laser (SSAIL)

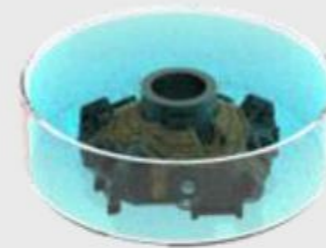
Laser surface modification



Rinsing & chemical activation



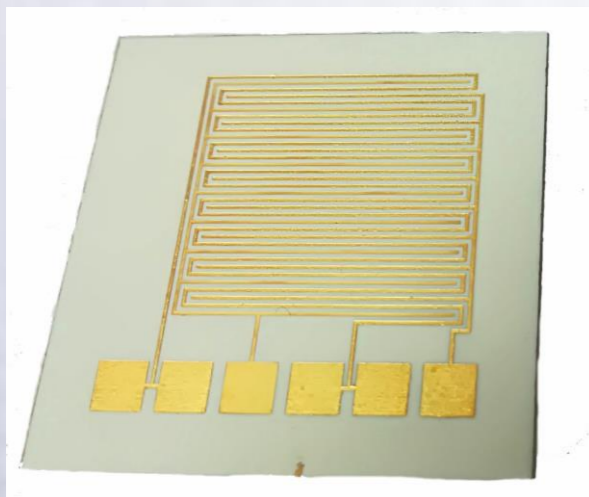
Electroless plating



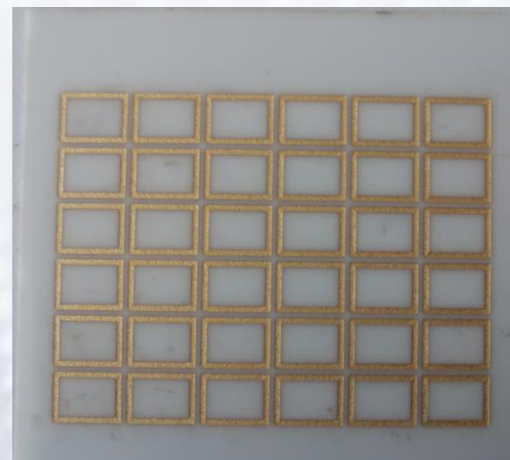
Final part



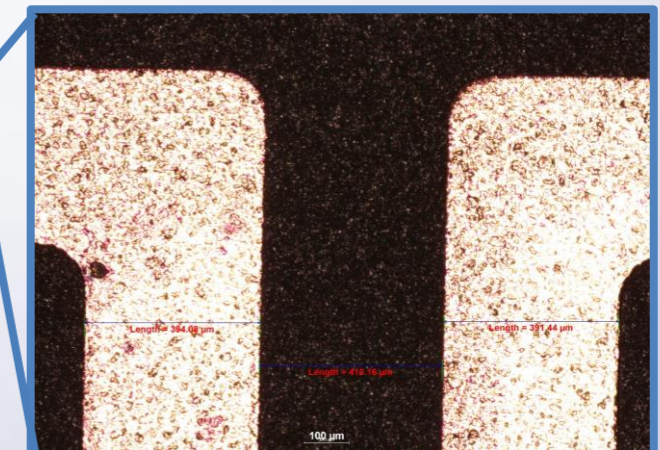
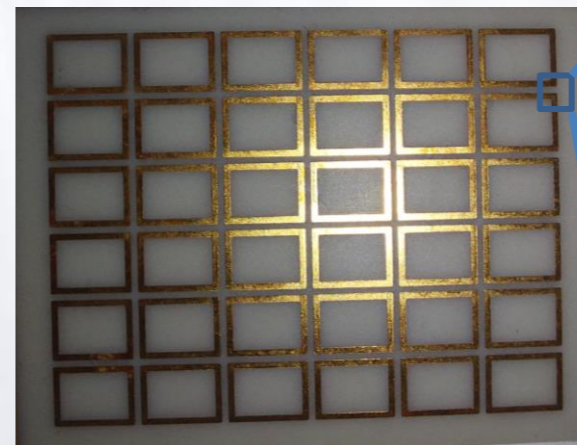
SITAL ceramic



Al_2O_3



AlN



Tasks in the project

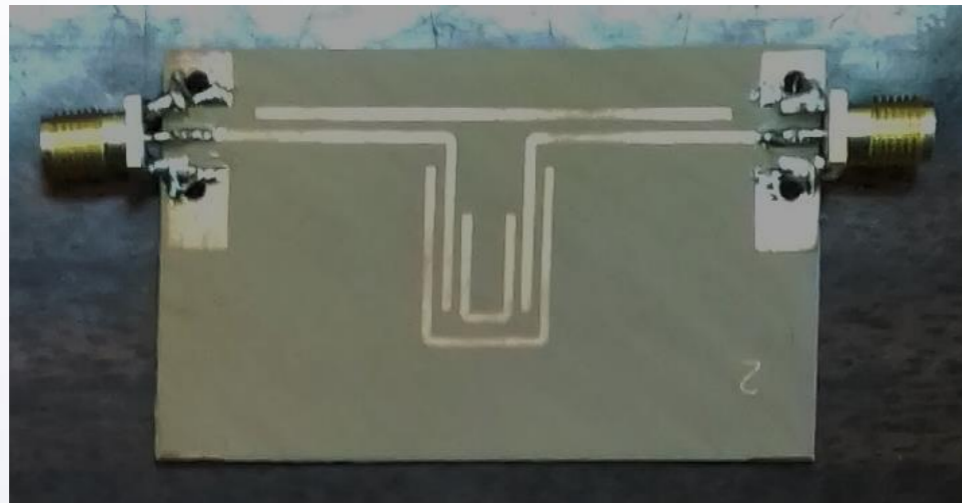
Simulation of new cells of metamaterials, studying their properties and microwave antennas based on the cells of metamaterials for energy harvesting and electromagnetic sensing.

Available equipment

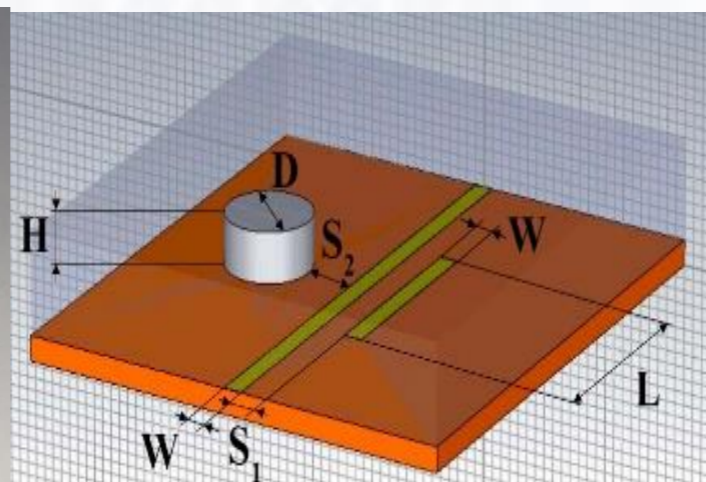
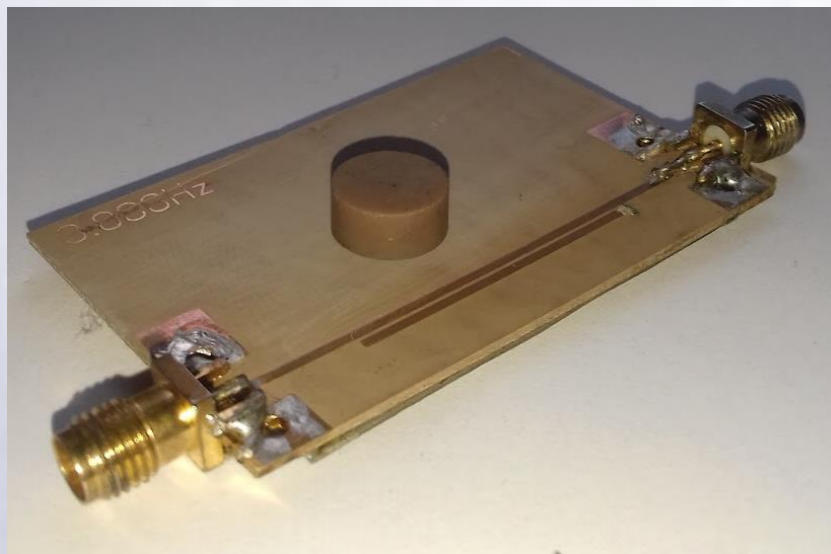
- HAMEG frequency synthesizer and spectrum analyser (up to 3 GHz)
- Signal Hound tracking generator and spectrum analyser (up to 4.4 GHz)
- Rohde & Schwarz FSG spectrum analyser (up to 13.6 GHz)
- Rohde & Schwarz vector generator (up to 3.3 GHz)
- Horn and parabolic antennas, waveguides, attenuators, phase shifters, directional couplers, and detectors.

This laboratory equipment will be used for experimental testing of rectennas (antenna with matching circuit and rectifier) based on dielectric and microstrip resonators for measuring efficiency of RF power conversion to DC power.

Metamaterial cells as a combination of microstrip resonators for microwave antennas



Combination of microstrip and dielectric resonators for microwave antennas design



Tasks in the project

The synthesis of new microwave materials with permittivity 10 to 150 and varied dielectric quality factor Q , and search for ways to control the dielectric properties getting the best match the design requirements for the created metamaterials.

Deliverables

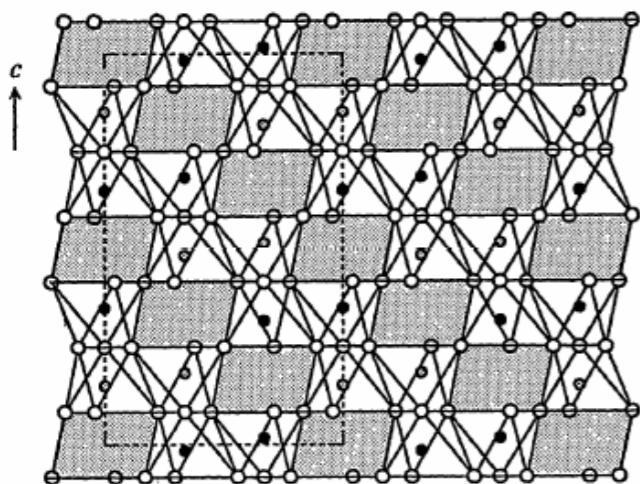
- the dielectrics based on multiphase systems with $Q_{10\text{GHz}} \sim 5000-7000$ and the volumetric thermal compensation effect.
- the dielectrics based on a mixture of perovskite and spinel phases with $Q_{10\text{GHz}} \sim 10^4$.
- the dielectric resonator prototypes with optimized parameters.

Preliminary preparatory activity for project:

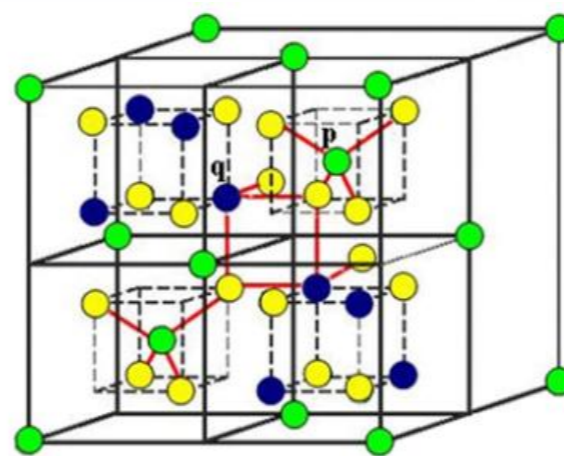
- First samples were synthesized and transferred to FTMC;
- One sample was tested by selective coating in FTMC.

Sample No	Permittivity	Quality factors Q at 10 GHz
1.	~ 20	$\sim 8000-9000$
2.	~ 35	3000
3.	~ 35	6000
4.	70-75	> 1000

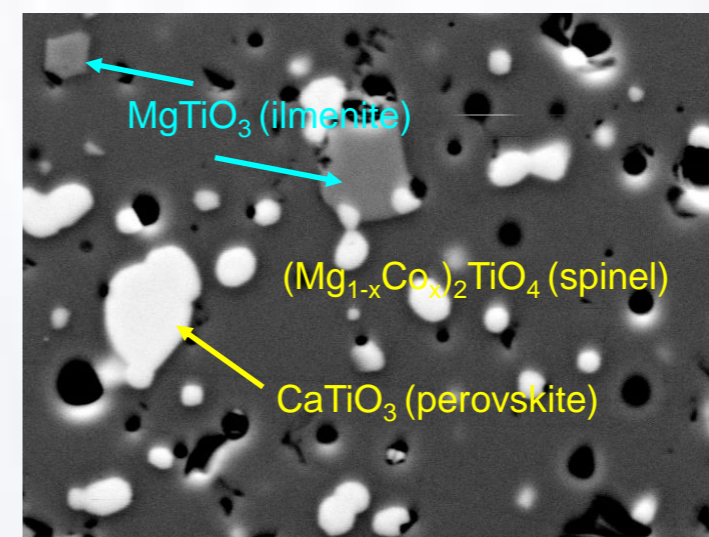
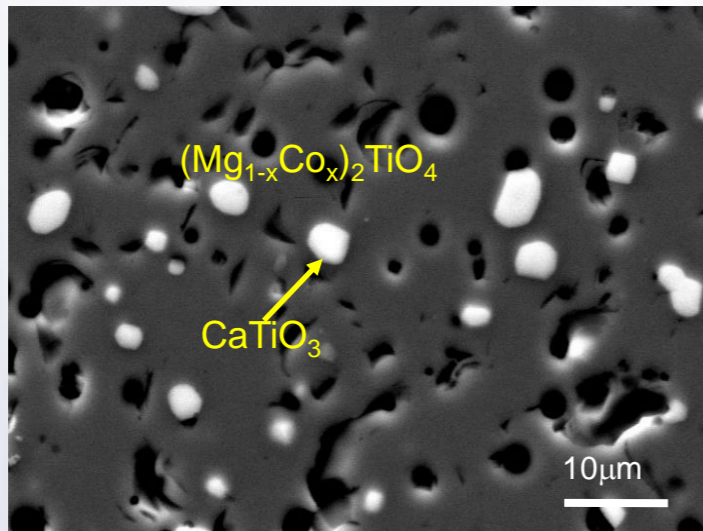
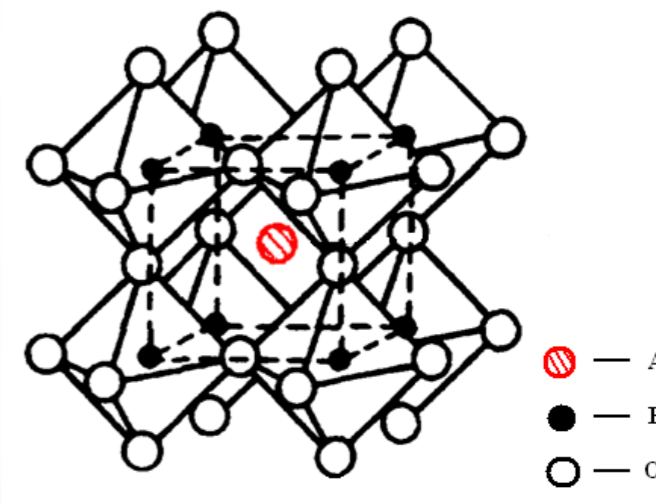
ilmenite



spinel



perovskite



Thermal-stable high-Q MW materials based on multiphase systems, which for the first time were synthesized by scientists of the team

WP No	Title	St. mn.	En. mn.	WP leaders
1.	Management	1	36	FTMC & KPI
2.	Development of dielectric resonator rectenna	1	30	KPI & FTMC
3.	Dielectric resonator rectenna fabrication and characterization	7	36	FTMC & KPI
4.	Dissemination, Public Outreach, Exploitation and Transfer of Knowledge	1	36	KPI

There are three WPs from four that are starting in the first month of the project. Therefore, we should concentrate on them and on three deliverables that should be released within the first six months.

Deliverables within first six months

The start of the project and the release of three deliverables should be the ground for the fulfilment of the all project

Deliverable	Description	Month of the project	Responsible
D1.1	Set up of a dedicated project webpage at the FTMC website	1	FTMC
D1.2	Project management plan	3	FTMC
D4.1	Communication and dissemination plan	6	KPI

In the table, I recorded the only responsible for the deliverable. On the one hand, If there are two or more responsible, everyone tries to transfer the responsibility to the other. On the other hand, it does not mean that all the jobs should be done by the responsible institution. It has to be divided between partners, and I do hope that if any partner asked for help it got it.

Project's Web Page

SCIENCE

STUDIES

INNOVATIONS

Science

[Home](#) > [Science](#) > [Projects](#) > [NATO Projects](#)

[Back](#)

- > Excellence
- > Long-Term Programs
- > Scientific publications
- > Conferences
- > **Projects**
 - EU Projects
 - [NATO Projects](#)

NATO Partnership and Cooperative Security Committee. Science for Peace and Security (SPS) Programme



NATO Partnership and Cooperative Security Committee
Science for Peace and Security (SPS) Programme

Project SPS G6002 -
"3D Metamaterials for Energy Harvesting and Electromagnetic Sensing"

NATO Country Project Director: Dr. Žilvinas Kancleris, Center for Physical Sciences and Technology (FTMC), Vilnius, Lithuania

Partner Country Project Director: Dr Mykhailo Ilchenko, Igor Sikorsky Kyiv Polytechnic Institute (KPI), Kyiv, Ukraine

Partner Country Project Co-Director: Dr Anatolii Belous, V. I. Vernadsky Institute of General and Inorganic Chemistry, NAS of Ukraine (IGIC), Kyiv, Ukraine

Project summary

This project will focus on the development of energy efficient, reliable and compact microwave rectennas and electromagnetic field sensors that will be used for energy harvesting of IoT devices, sensors, RFID systems etc. The proposed rectennas based on a metamaterial cell formed by a combination of dielectric (DR) and microstrip (MSR) resonators (DR&MSR). The proposed project corresponds to the NATO SPS key priority "1. Facilitate mutually beneficial cooperation on issues of common interest, including international efforts to meet emerging security challenges" and in the framework of this area covers current issues of "Energy Security".

Duration of the project 3 years, granted budget 350,000 €.

Remote kick-off meeting - 2023.06.07



Preliminary project's web page
on FTMC website

Address:
<https://www.ftmc.lt/nato-projects>

Start of important tasks

It is crucial timely start some tasks since others can not be started without the initial results of the former.

An example might be task 2.1 "Research for the best dielectric resonator antenna design", task leaders KPI and FTMC. Without the knowledge of specific parameters of dielectric resonators used in antennae, it is difficult or even impossible to start task 2.2 "Development of dielectric materials for dielectric resonator antenna".

Task 2.3 "Optimization of selective surface activation induced by laser technology parameters", in turn, can not be started without, at least, initial results of 2.2 and so on.

So I encourage KPI and FTMC, who are task leaders of task 2.1, timely start investigations since the chain of other tasks depends on the successful results of it.

Instead of conclusions

- The year back when we had started to prepare the project I, frankly speaking, have not believed that we will have finished the application in time. Fortunately, it happened, and, even more, our proposal got support from NATO. The joint endeavour of all participants let us get positive results.
- I do hope that jointly we successfully fulfil all the tasks of the project.