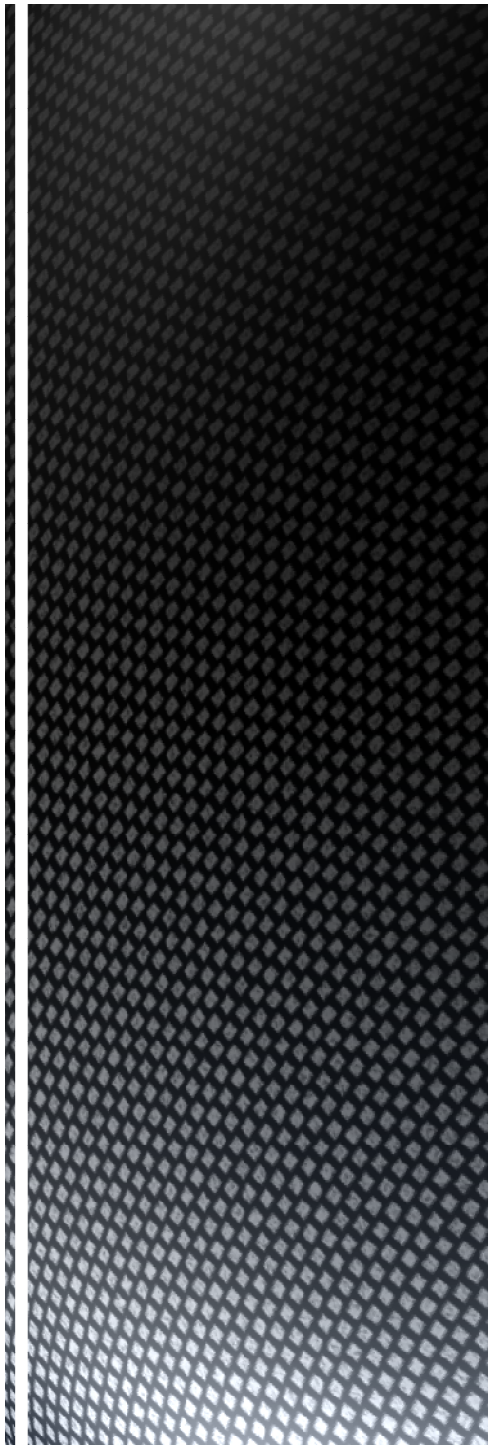
Programme for Research-Development-Innovation for
Space Technology and Advanced Research - STAR

Technology for manipulation and removal of dust for Mars missions TechDustMars

Cătălin M. Ticoş

Romanian Space Week , 12-16 May 2014, Bucharest, Romania



Project partners

- Coordinating organization:
  National Institute for Laser Plasma and Radiation Physics (INFLPR)
- Project manager
  Dr. Catalin M. TICOS, CS I
  Str. Atomistilor nr. 409, PO Box MG-6, Magurele 077125, Ilfov
  cata_ticos@yahoo.com, catalin.ticos@inflpr.ro

- Partner organizations
  S.C. UPS Pilot Arm S.R.L. (UPS)
  Institutul de Fizica Atomica (IFA)

- Partners team leaders
  Prof. Dr. Chereches Tudor (UPS)
  Str. Laminorului nr. 2, Targoviste, Dambovita
  Chereches.tudor@inflpr.ro
  Eng. Ovidiu Pacala (IFA)
  407 Atomistilor St., PO Box MG-3, Magurele 077125, Ilfov
  o.pacala@ifa-mg.ro

Project description

- Fine silicate mineral dust particles (10's nm to 1 mm) are a component of Mars atmosphere.
- The microparticles are electrically charged due to ionization by radiations and by mechanical factors (friction during storms).
- Dust is a hazard for missions because:

-it can block the bearings, joints and movable parts of tools or machines;

-it can cover the windows, solar panels, detectors;

-it can wear off the fabric of space suits;

-it is a potential health treat if present inside the human habitat.

Images from Mars during a dust storm:
the atmosphere becomes opaque
due to high dust concentration
(from NASA/JPL-Caltech/Cornell)

- **Project goal**

  we propose a **novel technology based on plasma jet for dust removal** from surfaces in low pressure conditions similar to those on Mars. **Our main goal is to produce a small experimental model based on a coaxial gun** which will be optimized for the conditions of Mars atmosphere.

Project details

- **Objectives**

Realization of an experimental model of a coaxial plasma gun for dust removal
Realization of a simulation model of the coaxial gun system
Demonstrate the feasibility of the experimental model at low pressure, in conditions similar to the Martian atmosphere.

- **Estimated results**

-publish > 3 papers in ISI journals
-give >3 presentations at international conferences
-fill a patent
-build a small prototype of a coaxial gun which removes dust in CO2 low pressure gas

- **Human resources involved:**

From INFLPR: 1 senior scientist CS I, several junior scientists (CSIII, CS, ACS), technicians
From UPS: 1 Prof. Dr., several engineers, technicians
From IFA: 1 engineer

- **Start date of the project / End date of the project:**

29 Nov 2013/28 May 2016 (30 Months)

Work plan of the project

It consists of **3 phases**:

- **Phase 1** includes hypotheses, theories and concept model of a coaxial plasma gun, and development of experimental and simulation models;
- **Phase 2** deals with the experimental evaluation of the effect of plasma jet on surfaces and simulation of plasma jet interaction with surfaces;
- **Phase 3** realizes the design of the experimental model, implementation of the technology which consists in building and testing of the dedicated coaxial gun.

  The final part of Phase 3 is demonstration of the functionality of the coaxial plasma gun and filling a patent presenting the technology.

Implementation status of the project

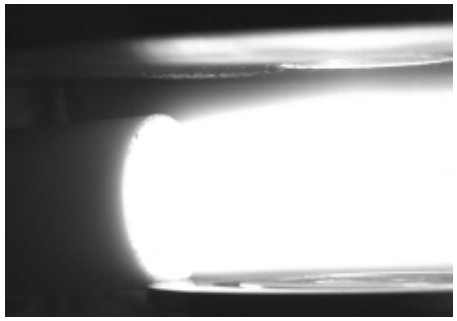
✓**Experimental implementation (INFLPR, IFA)**

-acquisition of equipments: high voltage (HV) source, pulse generator, puff gas valve, CO2 gas cylinder, vacuum parts, dust simulant.

✓**Numerical implementation (UPS, INFLPR)**

-acquisition of PC and software LS-Dyna which is a highly sophisticated software package which uses finite element analysis for solving complex differential equations with applications to fluid flows, shock waves, material strength.

Technology readiness level (TRL) at the start of the project: between 2 and 3

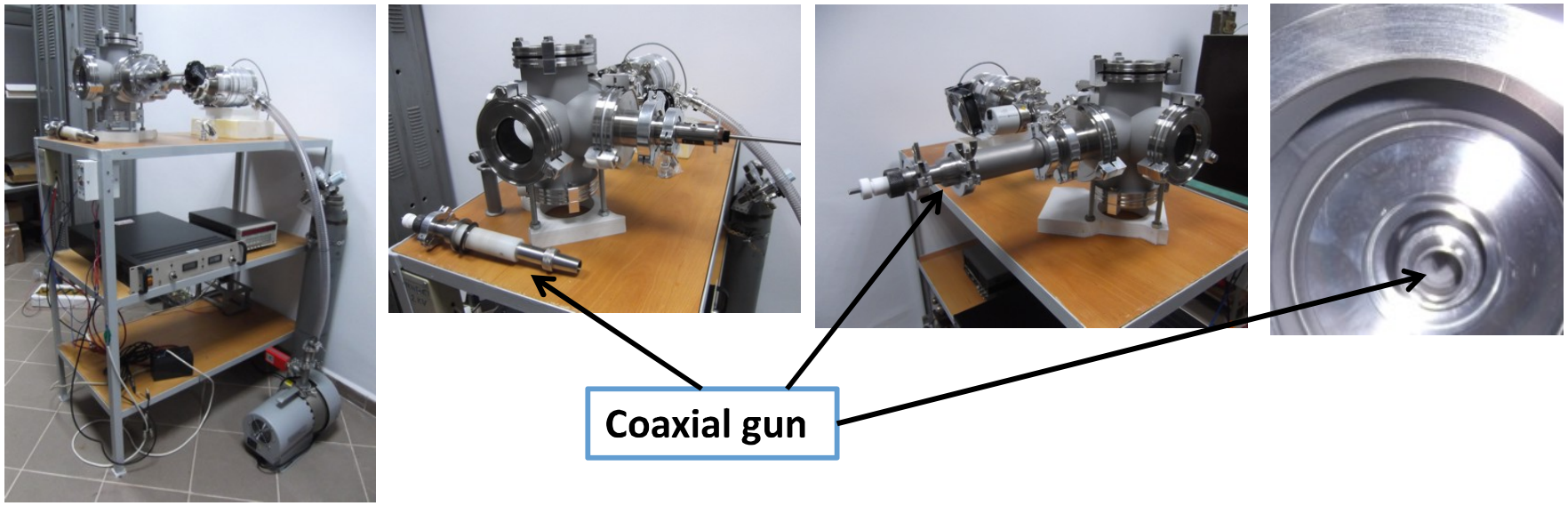


C. M. Ticos, I. Jepu, C. P. Lungu, P. Chiru, V. Zaroschi and A.M. Lungu
Removal of Floating Dust in Glow Discharge Using Plasma Jet
Applied Physics Letters ***97****, 011501/1-3 (2010).*

TRL at the end: aim for 5 (component validation in relevant environment)

Experimental setup (work in progress)

Coaxial gun mounted on a vacuum chamber:



Vacuum and gas system

✓Agilent scrollvac SH 110 and turbo V304 pumps
✓Fast gas valve Parker
✓CO2 gas cylinder and regulator
✓pulse generator Stanford (synchronization between video camera, gas valve and high-voltage (HV) pulse)

Power system

✓High voltage source Glassman-20 kV
✓Bank of capacitors 22 µF, 2x 500 mF
✓coax power cables RG213

Dust particles used for studies of dust removal efficiency

✓Martian dust simulant (brown color), Lunar dust simulant (gray color), made from volcanic ash

Particle size:

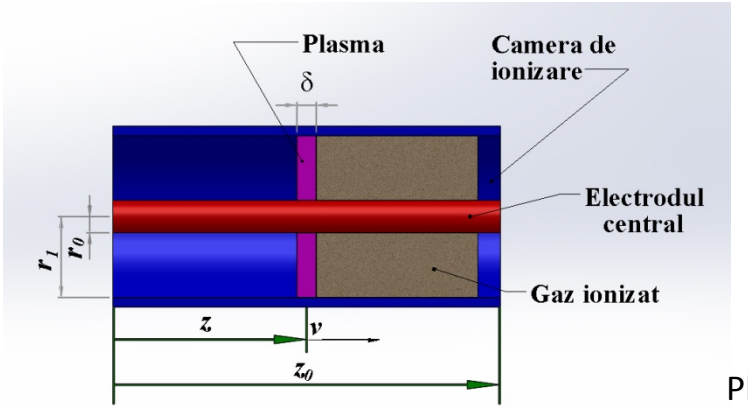
Φ=0.1 μm to 1 mm; Φ=1 μm to 5 mm; Φ=1 μm to 100 μm

Orbitech Technologies Corp., Madison, WI 53717, USA

Results: numerical simulations

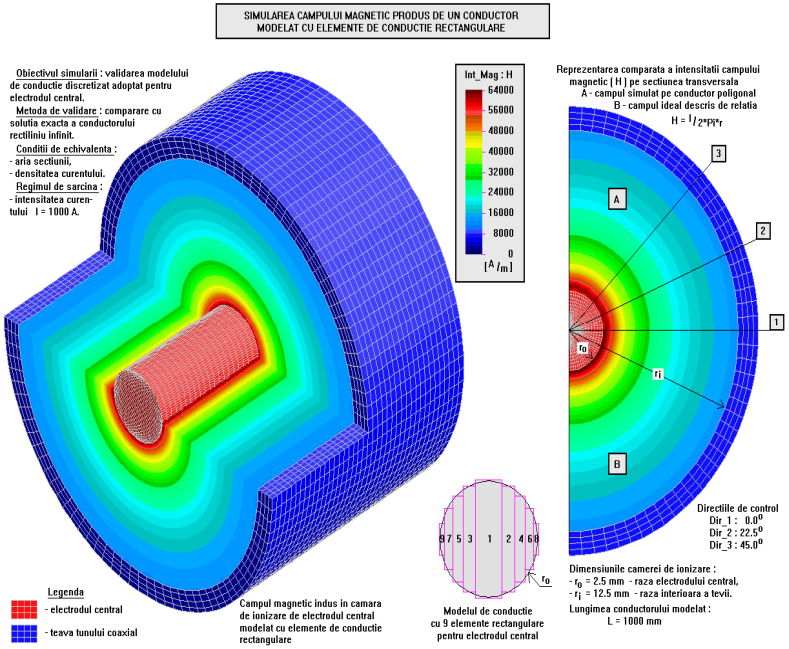
Simulations using LS-Dyna carried out mainly by UPS Pilot Arm SRL (and INFLPR)

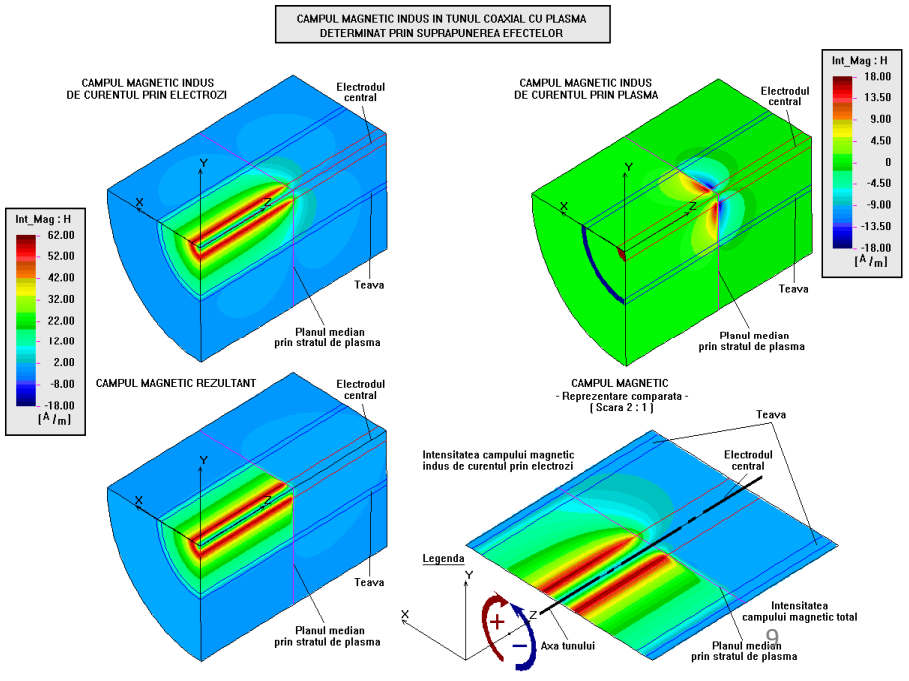
Model of coax plasma gun



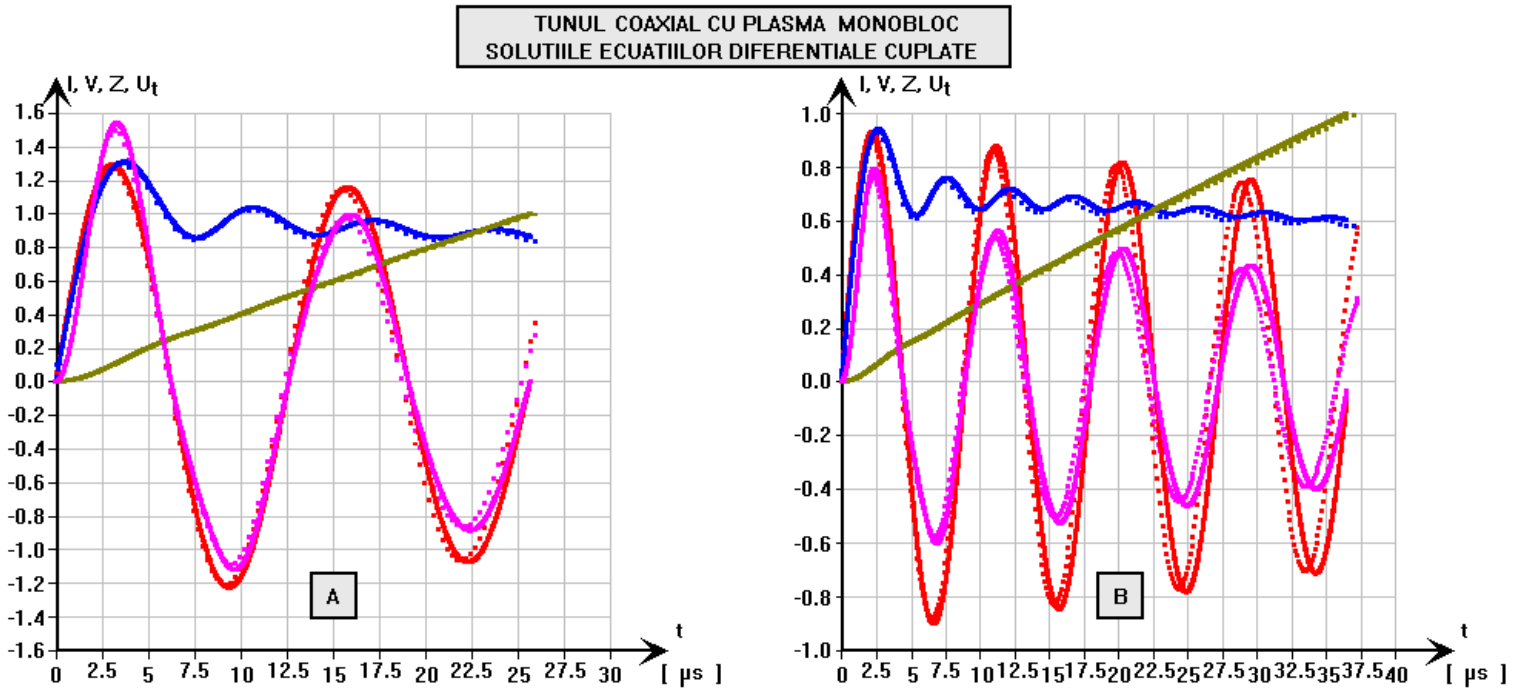
Plasma ionization inside coax gun

Magnetic field inside coax gun





Results: plasma jet speed, discharge current



A - Acordare pe doua perioade

Circuitul RLC acordat aproximativ

- Capacitatea condensatorului . C = 12.6 µF
- Durata descarcarii . . . . . Dt = 26.2 µs
- Viteza la gura tevii . . . . . V_0 = 4170 m/s
- Curentul maxim . . . . . I_{max} = 63.5 KA
- Tens_max. pe electrozi . $U_{t\,max}$ = 147 V
- Avansul la deschidere . . . . Av = 1.0 µs

Circuitul RLC acordat fin

- Capacitatea condensatorului . C = 13 µF
- Durata descarcarii . . . . . Dt = 25.7µs
- Viteza la gura tevii . . . . . V_0 = 4320 m/s
- Curentul maxim . . . . . I_{max} = 64.6 KA
- Tens_max. pe electrozi . $U_{t\,max}$ = 154 V
- Avansul la deschidere . . . . Av = 0.02 µs

Legenda

- I - intensitatea curentului
- V - viteza
- Z - deplasarea
- U_t - tensiunea pe electrozi

Factorii de scalare pentru functiile reprezentate in grafice

- intensitatea curentului . . . . . 50 KA
- viteza. . . . . 5000 m/s
- deplasarea. . . . . 120 mm
- tensiunea pe electrozi. . . . . 100 V

B - Acordare pe patru perioade

Circuitul RLC acordat aproximativ

- Capacitatea condensatorului . C = 6.32 µF
- Durata descarcarii . . . . . Dt = 37.4 µs
- Viteza la gura tevii . . . . . V_0 = 2990 m/s
- Curentul maxim . . . . . I_{max} = 45.4 KA
- Tens_max. pe electrozi . $U_{t\,max}$ = 76.1 V
- Avansul la deschidere . . . . Av = 1.6 µs

Circuitul RLC acordat fin

- Capacitatea condensatorului . C = 6.6 µF
- Durata descarcarii . . . . . Dt = 36.5 µs
- Viteza la gura tevii . . . . . V_0 = 3000 m/s
- Curentul maxim . . . . . I_{max} = 46.4 KA
- Tens_max. pe electrozi . $U_{t\,max}$ = 79.4V
- Avansul la deschidere . . . . Av = -0.16 µs

Project positioning within the STAR and ESA goals

- **Project's contribution to the goal of the STAR Programme**

The project fulfills the requests of the STAR grant call:

"CDI projects will be aimed primarily at conducting research which will lead to the development of scientific missions, technology development and application of space technologies and results in this area. For projects with industrial research and experimental development in partnership the presence of at least one private company is required"

"Achieving scientific and technological results at European level, as reflected by increasing visibility and international recognition of Romanian research."

- **Context and contribution to ESA Programmes**

✓ExoMars is an ESA program which has among its objectives the **investigation of the concentration of atmospheric dust, and to find the role of electric forces on dust lifting and of the mechanisms** which initiate dust storms. Other studies will focus on better understanding of the dust charging process.

✓The Mars Express program.

Dissemination activities planned in 2014

✓**European Physical Society Meeting – EPS 2014**, Berlin 24-27 June 2014

Oral presentation O4.J105 (Thursday 26.06.2014)

Dust removal from surfaces in a low pressure environment

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[1]*National Institute for Laser, Plasma and Radiation Physics, Bucharest 077125, Romania*

[2]*UPS Pilot Arm S.R.L, Targoviste 130089, Romania*

✓**COSPAR meeting, Moscow 2-10 August 2014**

Accepted abstract-B0.5

Dear ***Dr Ticos,***

On behalf of the Council of the Committee on Space Research, I am pleased to inform you that your contribution to the 40th COSPAR Scientific Assembly entitled: **Dust removal from surfaces in a Mars-like environment** has been accepted and scheduled for a poster presentation in scientific event **B0.5**. The room and exact viewing time will be communicated to you within the next month.

Conclusions

✓Work is on schedule as stated in the work plan

✓Experimental system almost ready for operation

More vacuum components are needed and will be purchased

✓Numerical simulations are delivering first results

Further refinements will be implemented in order to characterize the operation regimes of the coaxial gun

✓Young scientists are involved in the realization of the setup

✓Preliminary results will be presented at international conferences in June and August 2014