MICROWAVE BREAKDOWN IN SPACE BORNE RF EQUIPMENT

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Outline

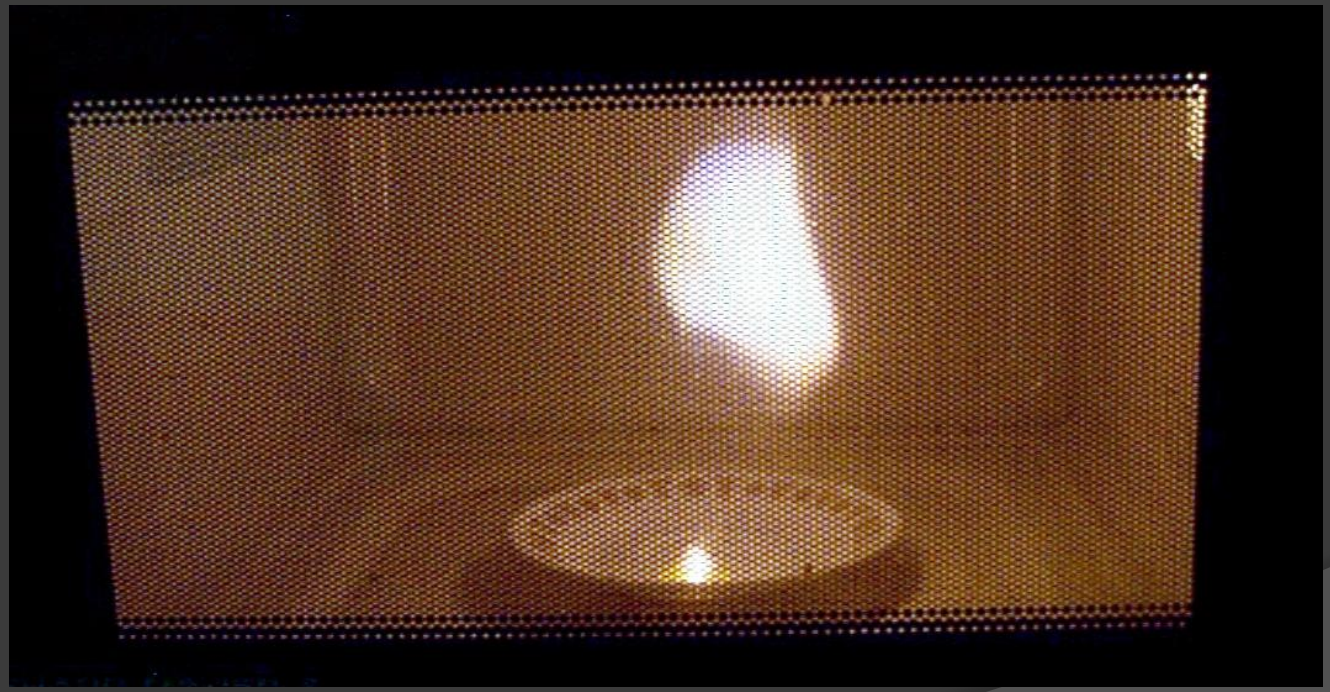
- Microwave breakdown in general (corona and multipactor)
- Multipactor breakdown
- Multipactor in inhomogeneous fields, previous work
- Multipactor in Helix-shaped antenna, ongoing work

Microwave breakdown in general

- Def: The avalanche-like growth of the number of free electrons in a microwave system.
- In gas-filled systems, e.g. air, this is called corona breakdown.
- In vacuum (space) we call it multipactor breakdown.

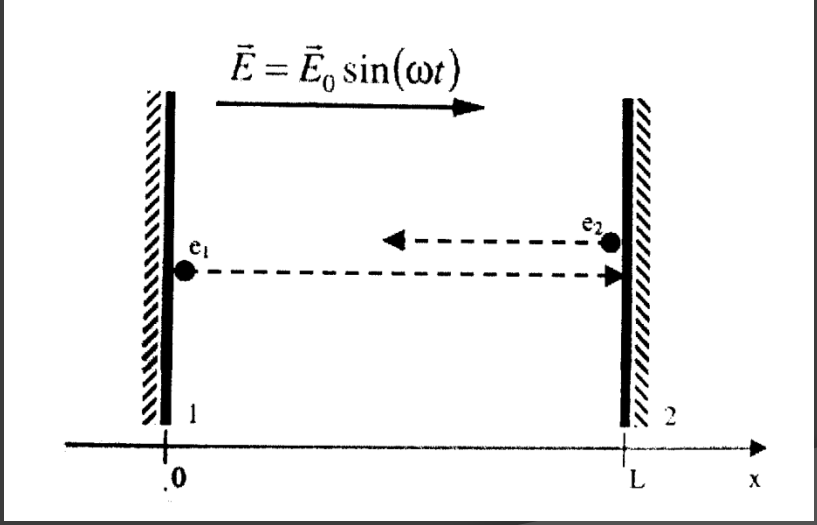
Microwave breakdown in general

- Corona: Electrons make ionizing collisions with neutral gas atoms, and molecules.
- For example, microwave oven plasma



Microwave breakdown in general

- Multipactor: Electrons multiply by kicking out secondary electrons from surfaces.
- Classical (ubiquitous) case of infinite parallel plates.

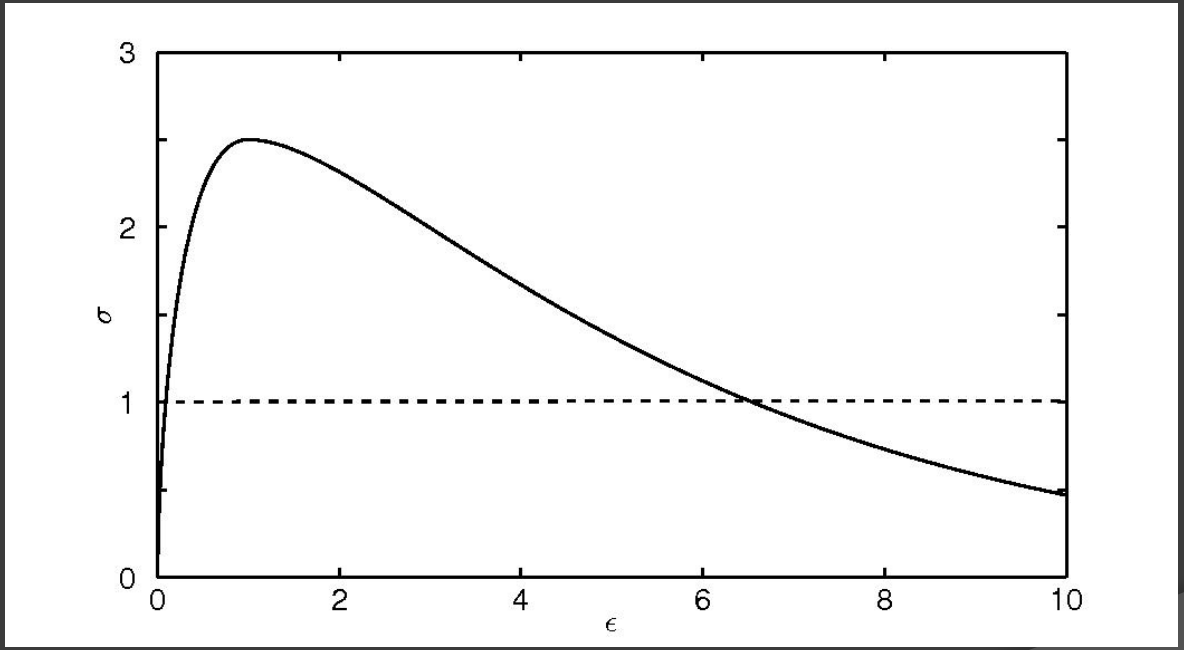


Microwave breakdown in general

- Microwave breakdown may change the device impedance, generate noise, heat device walls, and even permanently damage the hardware. The corona breakdown in atmospheric pressure will produce substantial amounts of heat, even melting protruding metal parts.
- We want to avoid breakdown; calculate the electric field breakdown threshold.

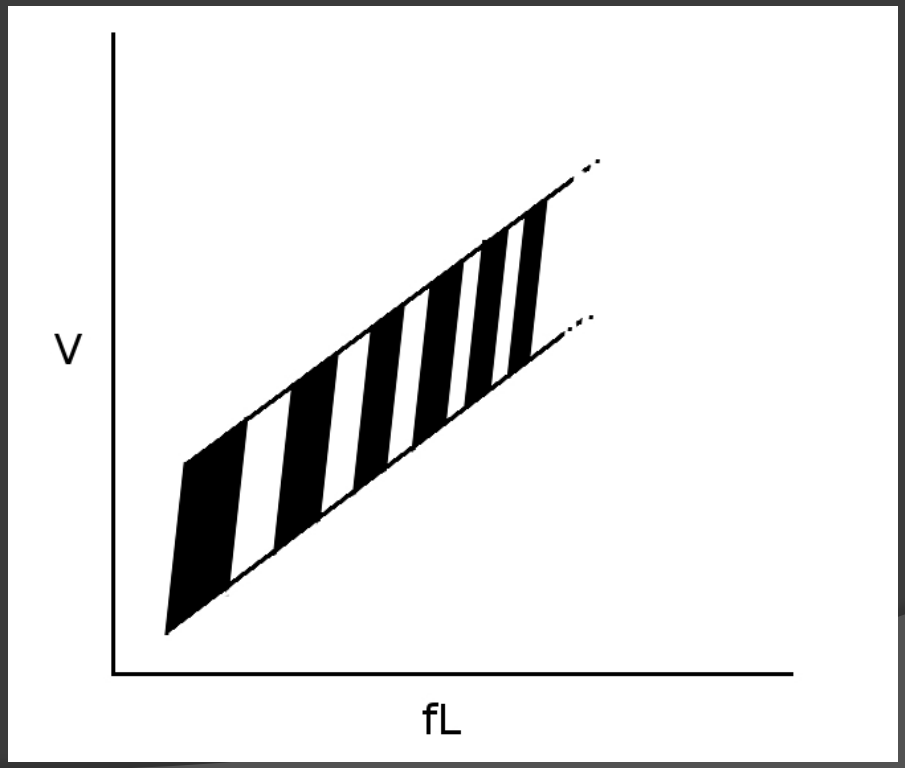
Microwave breakdown in general

- The infinite parallel plates breakdown requires sufficient electric field strength



Microwave breakdown in general

- The gap width together with the field frequency must fulfill resonance conditions.



Microwave breakdown in general

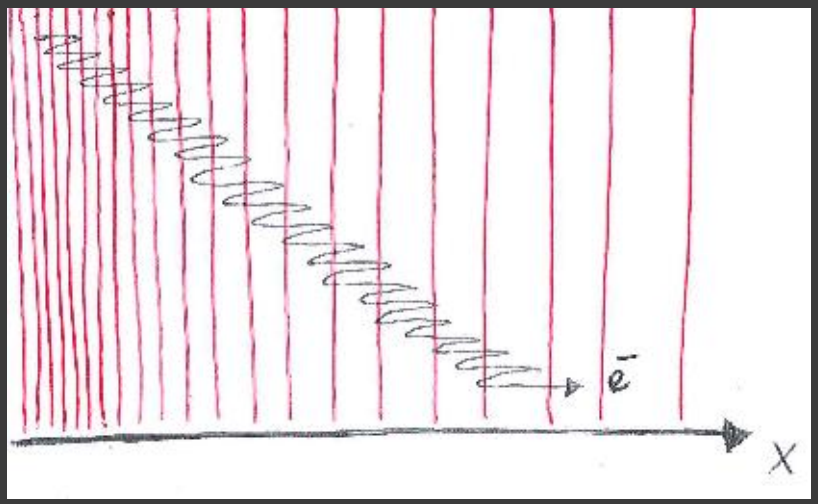
- Many studies have been made of the parallel plates case, because it's the easiest situation (homogeneous field). Complications have been added in the form of; stochastic signals, different materials, non-vacuum, magnetic field, etc.
- The research on nontrivial geometries (inhomogeneous fields) is limited.

Multipactor in inhomogeneous fields, previous work

- Our group have been collaborating with CNES (Centre National d'Etudes Spatiales) in Toulouse and IAP (Institute of Applied Physics) in Nizhny Novgorod for several years, researching nontrivial geometries.
- For example: rectangular waveguide, waveguide iris, coaxial waveguide.

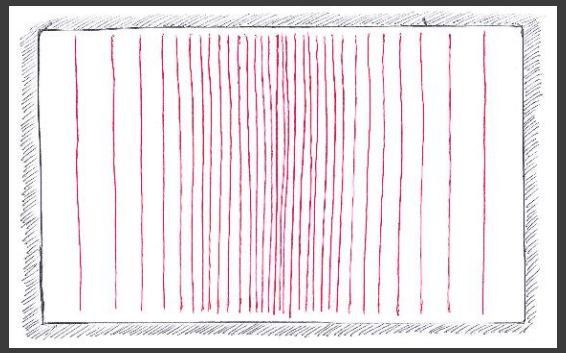
Multipactor in inhomogeneous fields, previous work

- Inhomogeneous fields introduce the ponderomotive force as an electron loss mechanism.

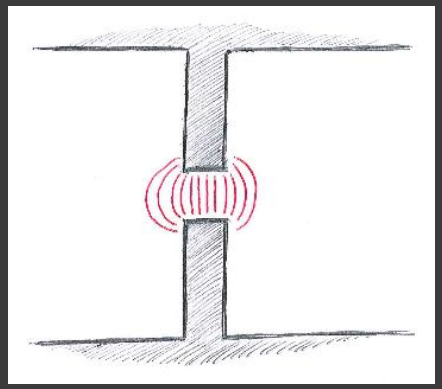


Multipactor in inhomogeneous fields, previous work

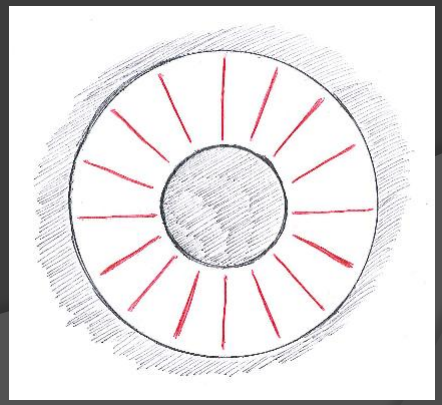
- Rectangular waveguide



- Waveguide iris

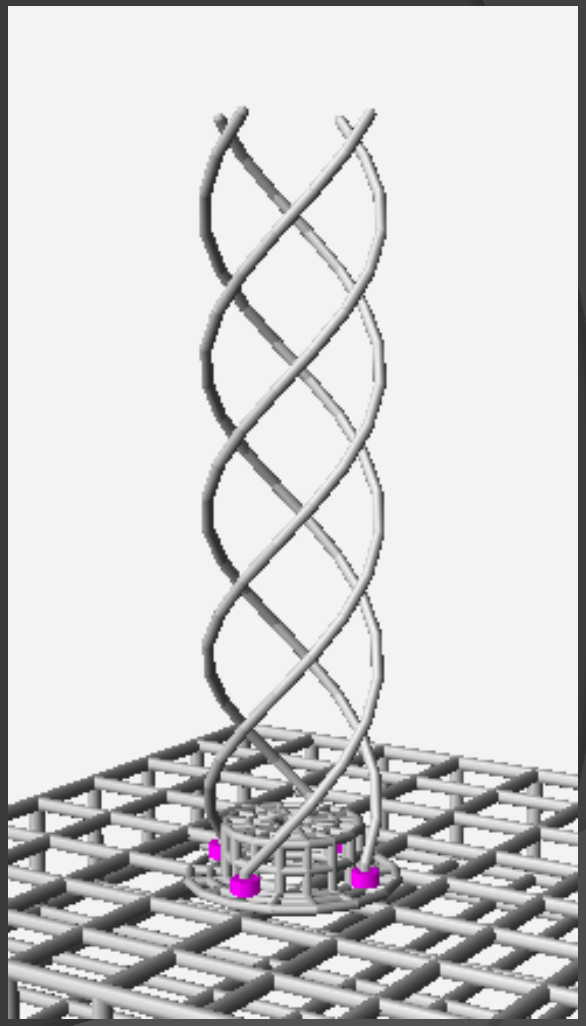


- Coaxial waveguide



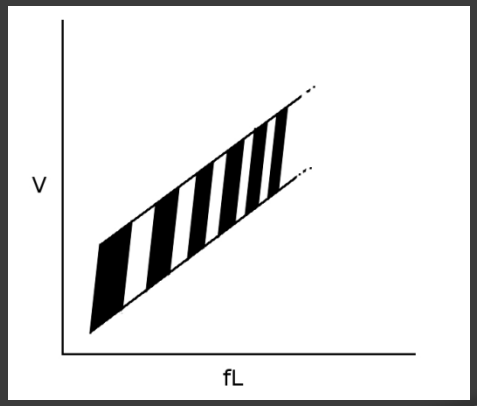
Multipactor in Helix-shaped antenna, ongoing

A cooperation between Chalmers, RUAG, CNES, and IAP, supported by a grant from NRFP (Nationella Rymdforskningsprogrammet).



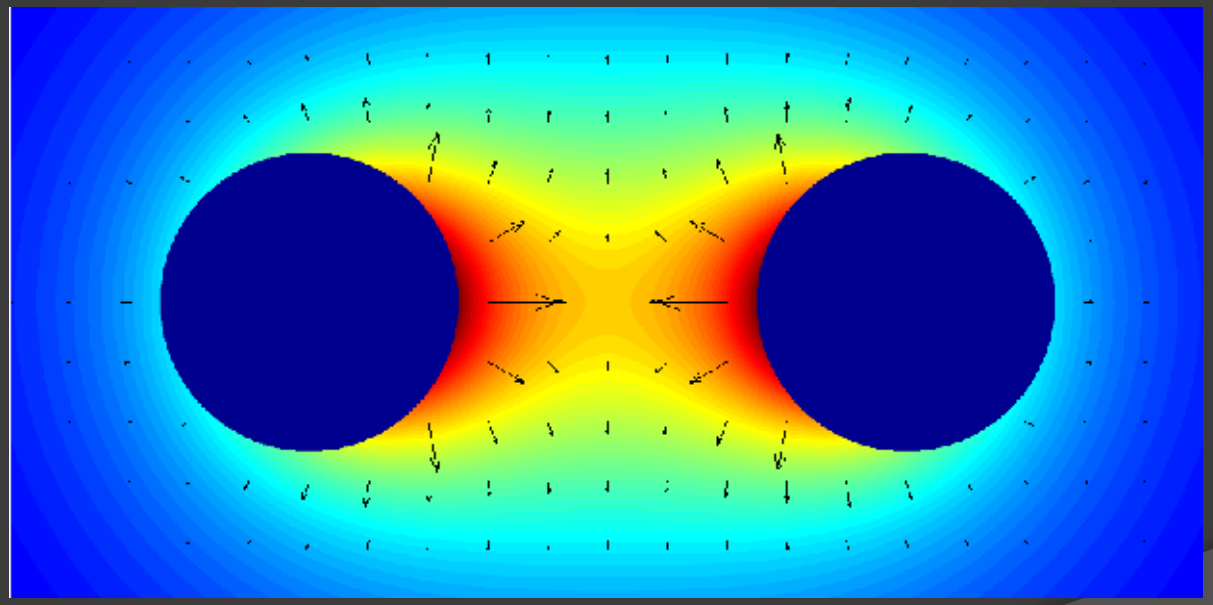
Multipactor in Helix-shaped antenna, ongoing

- As a starting point, the simpler geometry of two parallel metal cylinders is considered.
- We discard the resonance conditions and look on the lower threshold for multipactor.



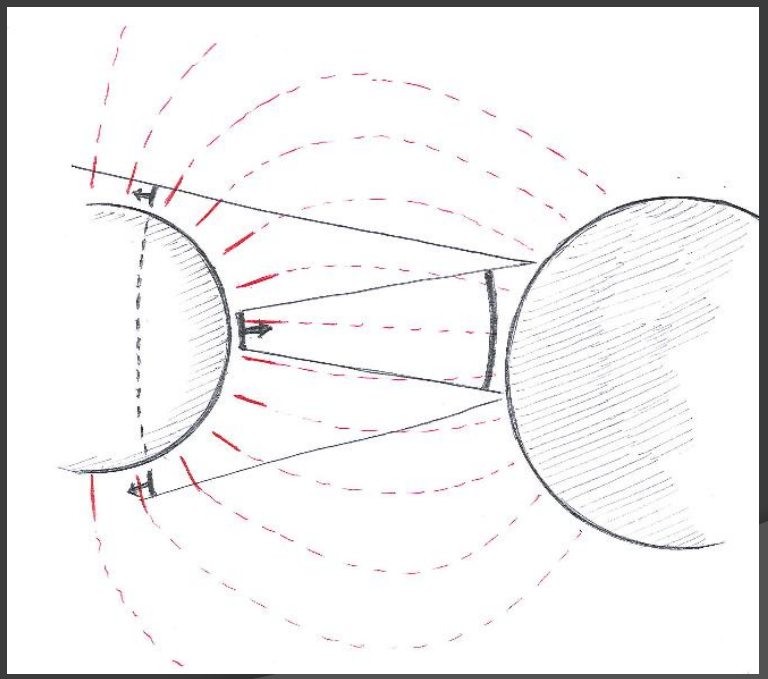
Multipactor in Helix-shaped antenna, ongoing

- We naturally have electron losses from the ponderomotive force.



Multipactor in Helix-shaped antenna, ongoing

- We also have a ’new’ loss effect caused by geometrical spreading of electrons due to the electric field being normal to a curved surface.



Multipactor in Helix-shaped antenna, ongoing

- With these two loss mechanisms and the exact expressions for the electric fields, we can calculate the absolute lower field strength limit for two-sided multipactor breakdown.
- Multipactor is very unlikely for normal materials and small radii.

Multipactor in Helix-shaped antenna, ongoing

- For example; f=8 GHz, r=0.6 mm, d=5 mm => σ=7.3.
  Most space materials have a maximum secondary emission yield of 2-3.

- J. Rasch et. al., *Microwave multipactor breakdown between two cylinders*, IEEE Transactions on Plasma Science. (To be published)