Some Results from the Autopsy of the T53VG3R structure

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Input coupler Picture
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During breakdown, a few kA of electrons are produced in less than 100 ns, with an energy up to ~100 keV. Few A of ions are also produced, with an energy up to 30 keV. (Waveguide Simulation - V. Dolgashev)

Electrons induced:
- Secondary Electron Desorption
- Molecular Gas Desorption
- Enhanced molecule diffusion in the bulk.
- Ionization of the residual gas
- Heating of the surface
- Deposition of carbon on the surface

Ions induced:
- Secondary Electron / Ion Desorption
- Molecular Gas Desorption.
- Ionization of the residual gas
- Heating of the surface
- Sputtering of the surface (happens during rf breakdown ??)
Diagnostic Tools Setup

SEM Setup
Electron/Specimen Interactions

When the electron beam strikes the sample, both photon and electron signals are emitted.

X-rays
Through Thickness
Composition Information

"EDX"
0-2000 nm depth

Incident Beam

Primary Backscattered Electrons
Atomic Number and Topographical Information

"BSE"
500 nm depth

Sample

Secondary Electrons
Topographical Information

"SEM"
1-5 nm depth

Auger Spectroscopy
“AES”
1-3 nm depth
Autopsy of the Input Coupler: Drawings

Secondary Electron Microscopy: Analysis within the red circle

-see below
Low-z material, or charged up insulator.
Zoom of the Lower Right Horn

- Extra heating due to rf current flow?
- Ion bombardment during rf breakdown?
- Electron bombardment?

Side of the horn badly damaged
Debris due to T53 cutting (blue circles)

Braze joint: good
Typical feature of the floor of the coupler

Droplet of copper on the braze joint
Zoom of the Upper Right Horn 3
Upper Left Horn, WG side
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Upper Left Horn, Cavity side

200 µm
Lower Left Horn Cavity + WG side
Lower Right Horn, WG side
Lower Right Horn, Cavity side

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General Observations

- Melting damage is systematic on all the horns edges facing the cavity side.
- No such damage exists on the waveguide side of the horns. However, some craters can be seen at the surface of this edge.
- Craters can be also seen on all the faces of the horns, with very low density on both side of the edges compare to the face between the edges.
- All these areas are, however, a low electric field zone!
Field distribution in T53VG3 coupler

Surface electric field distribution, max. field in the coupler cell 140 MV/m, power 48 MW

Surface magnetic field distribution, field on a flat part of the coupler iris ~0.28 MA/m

Pulse heating of T53Vg3 coupler waveguide iris, R=76µm

Surface magnetic field distribution

Surface temperature distribution, 400 ns pulse, 48 MW, maximum temperature 127 deg. C.

Mesh

V.A.Dolgashev, 03 May 02.
Rf pulse heating:
According to simulation done by V. Dolgashev, the T° rise will be less than 130°C ±30%, from meeting on 15/05/02
This is not high enough to explain the melting.

Ion bombardment:
Pulsed ion bombardment may produce such damage. However, this is a very low E field area, the gas density is not high enough, and the localization of the damage does not support the hypothesis. So it cannot be ions from the vac.
Can it be ions crossing gaps, local breakdown due to the current-induced by the B field? Ions coming from some other breakdown site, following a new E field line?

Rf pulse heating, resistive loss:
High current, induced by B, flowing along sharp edges, having higher resistivity, might be enough to reach melting temperature. Surface defects existing or induced by thermal fatigue may act as sharp edges.