Experimental breakdown studies – breakdown diagnostics

Linking simulation and experiment

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The connection between simulation and experiment

**Emitted currents**
- Dark current spectrum
- OTR
- X-rays
- Trigger mechanism
- Missing energy
- Breakdown rate
- Ion currents
- Fowler-Nordheim distribution

**Plasma characteristics**
- Time structure
- Physical dimension (imaging)
- Ion species (opt. spectroscopy)
- Ion currents
- Vacuum behavior

**Surfaces**
- Crater morphology
- Material diagnostics
- Fatigue process
Breakdown diagnostics

Plasma density: simulation input

Plasma composition: simulation and mat.sci. input

Plasma size/position: simulation and design input

RF measurements, FC, XRAY: simulation and design input

OTR in nominal pulses: simulation and machine parameter input

Missing energy?

SEM: simulation and design input

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Breakdown diagnostics: some results

**DC**

Copper DC OTR spectrum, single shot, 6kV

**RF**

Copper RF OTR spectrum, TM02, 10min@5kV

**Opt. spectroscopy**

DC ED spectrum, 5.5kV Cu, condensed, GE corrected

**Found Cu I, Cu II, Cu III ions**

Will be measured soon at SLAC

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Breakdown diagnostics

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Breakdown diagnostics: some results

- Spectrum typical for OTR in Cu (interband transition @ 2.1eV)
- Beta measurements possible close to the breakdown limit (~10^5)
- OTR sometimes seems to rise before a breakdown
- Oxide layers suppress OTR
- An estimation of the energy absorbed by electrons in 30GHz structures: 0.1MW @ 14MW RF input power

- Found very little traces of O,H, probably no contribution to the breakdown physics
- Estimated temperature from two-line-method: 1-5eV, but Cu III (T>35eV) seen, plasma is a non-LTE plasma!
- Intensity waveform for different lines highly non-reproducible (clusters? Different plasma?)
- Density measurement under planning
Breakdown diagnostics: further measurements

RF

DC

RF (I,Q, Xray, FC @ 30GHz)

Current, voltage and delay

SEM of single breakdowns

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New measurements Raw data from today!

RF
- C10
- 40ns
- 40MW
- 2min integration

DC
- Copper conditioned
- 4.8kV
New measurements  Raw data from today!

RF

DC: OTR spectrum
Conclusion

- High resolution optical spectroscopy in DC and RF almost done
- Time resolved measurements will follow
- There are differences in the continuum background for DC and RF
- C10 does not show OTR like expected, have to check 30GHz TM02 again
- Traces of oxygen and hydrogen have been seen during multipaktor events
- Breakdowns seem to emit less line-like radiation and more continuum background than multipaktor
- Interpretation of the data is ongoing…

THANK YOU!