High Gradient RF RD

Breakdowns cause damage ↔
Breakdowns are required for high gradient

Processing phenomenology

Marc Ross
Questions:

- Which breakdown events cause damage?
  - Categorization by:
    - Location, missing E, timing (within pulse), timing (wrt other events), threshold, multi-location...

- Which processing strategies minimize damage?

- Tools:
  - RF, x-rays, beam, light, sound, vacuum
  - (using these for DS2S/DDS3, these are coming soon)
Correlated breakdown events

• 3 types of breakdown events in DS2S:
  – occurs following very many nominal pulses (A)
  – occurs on the next pulse or directly following an abnormal pulse - ‘multipulse’ (B)
  – occurs during the ramp up/recovery from a fault - ‘spitfest’ (C)
• we know (from RE/Load forward RF signals)
  – (A)
    • has no ‘pre-cursor’ or warning RF signal
    • usually appears to be in the beginning of the structure
  – (B)
    • usually moves forward as the sequence progresses
    • always occurs early in the pulse
  – (C)
    • does not appear to be in the same place in the structure as initial (earlier) fault (?)
    • can happen at very (10%) low input power
    • often appears at the ‘steps’ in the ramp-up sequence
Beam, Light, Sound and Vacuum

- **Sound:** ‘Acoustic Emission Sensors’ (0.05 – 1MHz)
  - Pulse heating detectors
  - Breakdown location and energy
  - Inter-pulse
  - Very useful, clean signals

- **Vacuum:** RGA
  - Surfeit of H2 in steady state
  - CO produced in breakdown

- **Light:** Coming very soon

- **Backwards beam:** very soon
DS2S input coupler acoustic emission sensors

Jan. 4, 2001  
Coll. Video Mtg.- High Gradient RD  - Marc Ross
DS2S acoustic emission sensors
Acoustic signals from breakdown

- 4 sequential pulses;
- 2200 pts @ 50ns/pt (112us)
- Time synchronized with Veetest scopes:
  - 11/27 01:41:41 (acoustic)
  - 11/27 01:41:30 (Veetest)
- Missing FE – 39%
- Loc 1 - 26 ns
- Loc 2 – 6 ns

Data record

2001127014141.DAT

RE/FE computed loc. (frac structure length)

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Acoustic signals from breakdown

- 4 sequential pulses;
- 2200 pts @ 50ns/pt (112us)
- Time synchronized with Veetest scopes:
  - 11/27 02:39:27 (acoustic)
  - 11/27 02:39:06 (Veetest)
- Missing FE – 81%
- Loc 1 – 35 ns
- Loc 2 – 10 ns

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Acoustic signals from breakdown

- 4 sequential pulses;
- 2200 pts @ 50ns/pt (112us)
- Time synchronized with Veetest scopes:
  - 11/26 23:12:52 (Veetest)
- Missing FE – 49%
- Loc - 7 ns
Acoustic signal propagation

- Leading edge start downstream of sensor 3
- Sensor location vs start time
Conclusions

• (not completely consistent with RF signal results)

• Many large breakdown events show upstream activity

• ‘spitfest’ events not necessarily in the same location
  – If not, how do we interpret ‘multi-pits’