# Gold Circuit Electronics

Materials Development Focus

November 19th, 2009

IBM Symposium

- Effective characterization and introduction of new printed circuit board materials into mass production is a need.
  - **Signal integrity (5GHz performance --→ with 10 GHz understanding)**
  - **Excellent reliability for lead free assembly (245C to 260C exposure, for 5 to 6 exposures, including robustness for all assembly possibilities)**
  - **Full range of technology and thickness → understanding the Design limit for recommended materials is vital to success, strong part number / process interaction verification needed "real time**
- IBM methodology incorporated into Gold Circuit Electronics standard system, most specifically regarding HOP31b, CAF resistance and SPP (short pulse propagation) testing.

I. High speed and Lead free requirements have resulted in a proliferation of products in the supply chain

II. Comprehensive and accurate assessment is vital to customer and market alignment

III. 3-phase methodology established



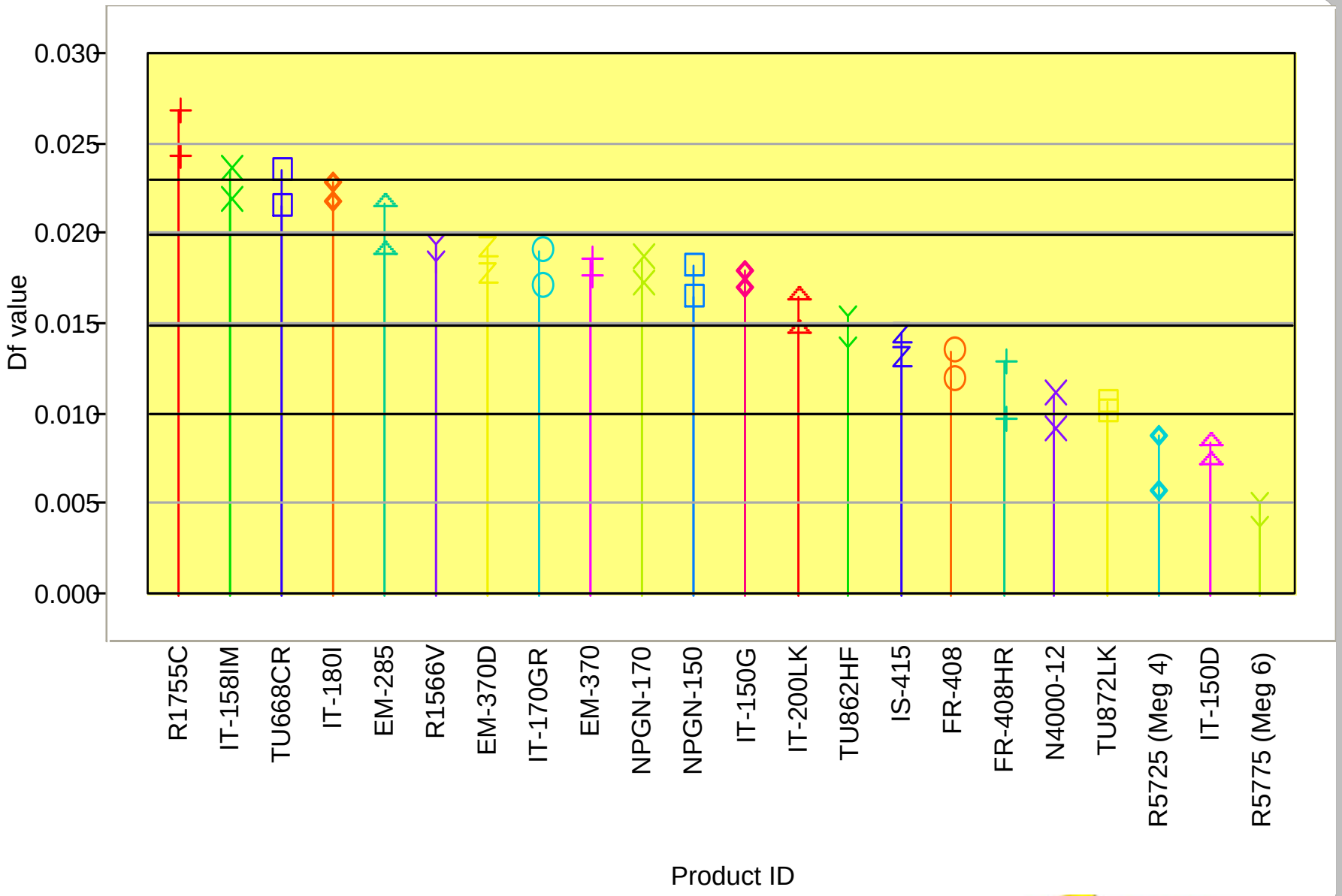

# Methodology

- **Initial Evaluation: - Material type and feasibility assessment:**
  - Intrinsic property:
    - Formulation:
      - Resin, Fillers, Curing Agent, Coupling Agent & Glass Cloth
    - Electricity:
      - Dielectric constant, dissipation factor, dielectric electrical strength.
    - Thermal reliability:
      - Time to blister, decomposition, cohesion and adhesion strength under thermal load or cycling, solder temperature impact index.
    - Physical property:
      - Effect of moisture, material expansion, bond strength, nature of filler, uniformity

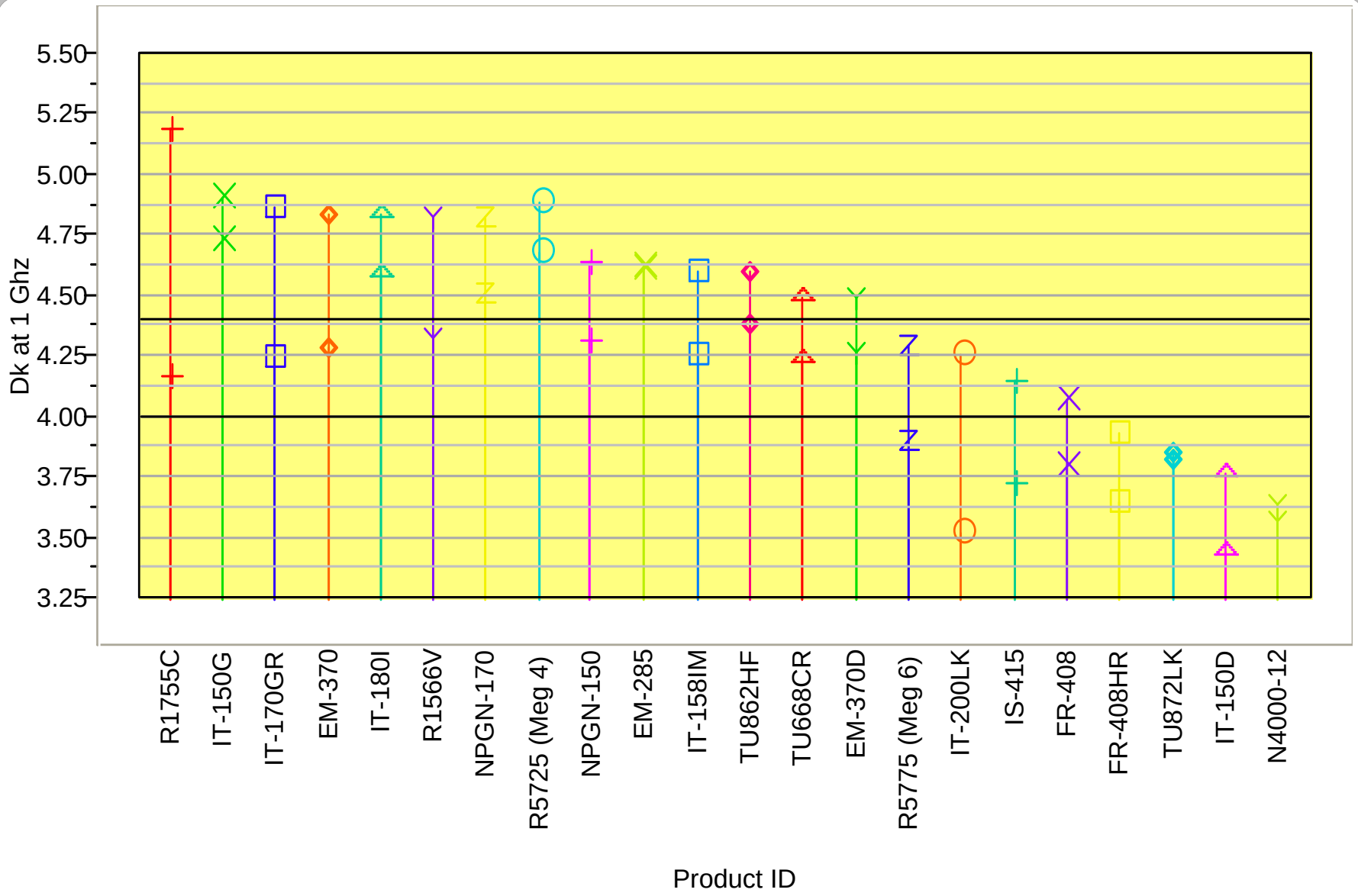
# Methodology

- **Initial Evaluation:  - Material type and feasibility assessment:**
  - Materials maturity:
    - Technical support, Productivity, Delivery, Cost
  - UL status
  - Intellectual property  - legality review and status, as applicable
  - Marketing
    - Application history and success.
    - Third party validation


# Methodology




# SPP measurements – Df



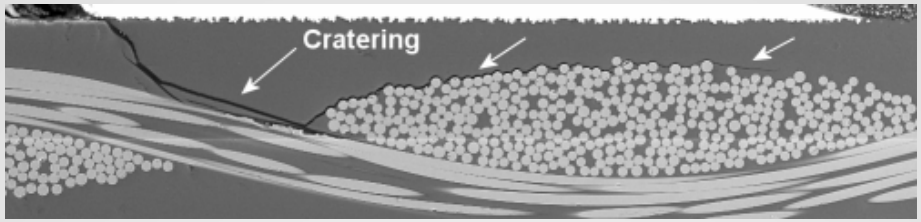

# SPP measurements – Dk

- **Process certification.**

  - Process test (all areas)
    - Primary focus
      - Lamination – melt viscosity, flow, time, temperature and pressure optimization, compatibility with oxide, moisture and hold time control.
      - Drill – tool wear, small and mid size hole, smear generation, peck drilling, material interaction
      - Plasma/De-smear – chemical resistance, weight loss, part number design contribution
      - Plating – copper thickness uniformity, copper bond strength
      - Impedance. – dielectric thickness and property consistency and impact on uniformity of impedance, foil type and property )

# Methodology

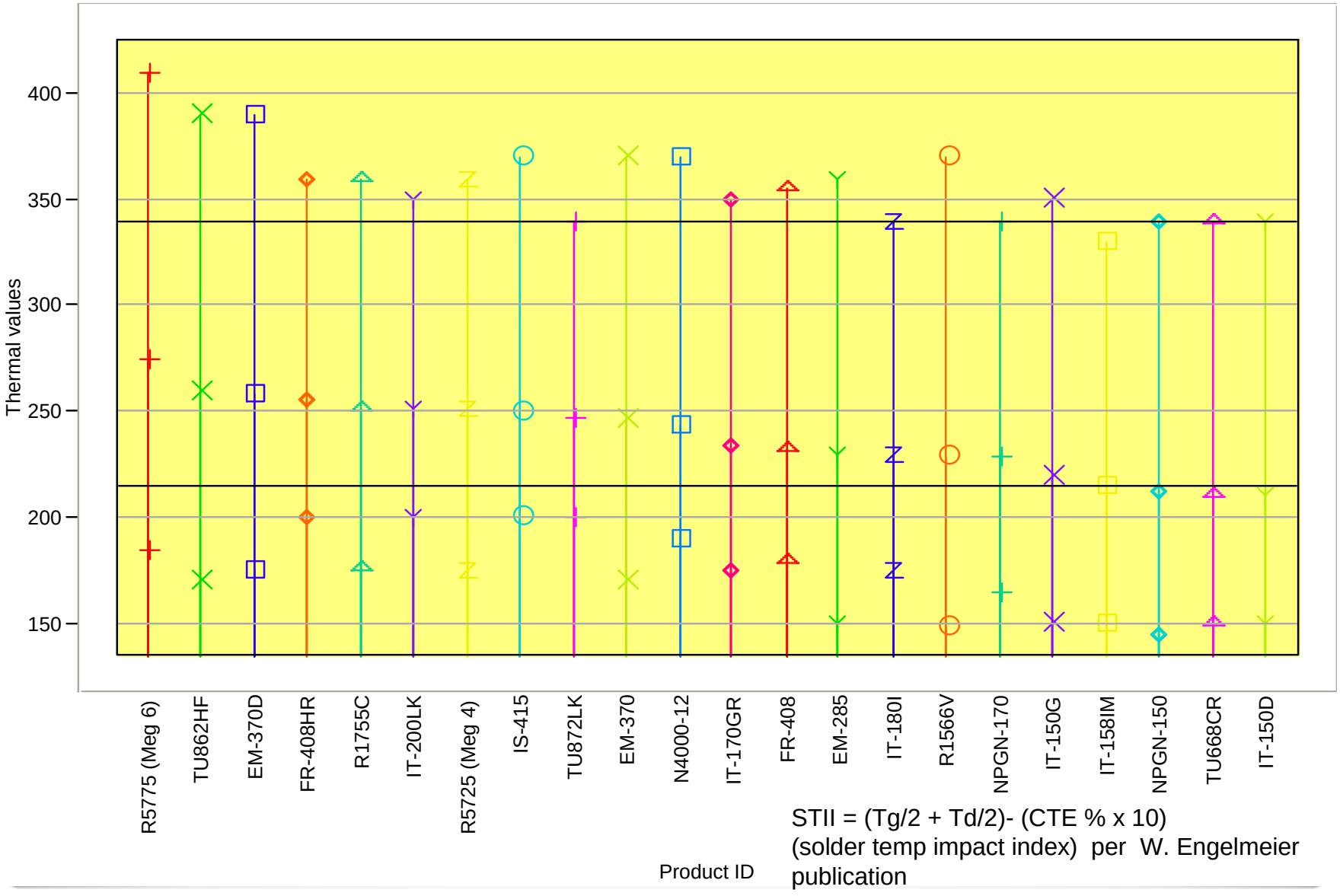
- **Process certification. -**GCE new materials process certification report
  - Reliability test:
    - Interconnect Stress Test (500 and 1000 cycles to fail)
    - Cathodic Anodic Filament resistance (300 and 600 hours)
    - Accelerated Thermal Cycle,(600 and 900 hours)
    - Reflow & Solder reflow report. (6x 260C)
    - “Other” PFMEA (potential failure mode element analysis) result
      - Fracture toughness (pad crater/material cracking)
      - Change in mechanical nature after reflow




# Methodology

- **Mass Production Readiness.**
  - Mass-production:
    - Refinement of FMEA failure modes and effects analysis
    - Material availability and stock control and Supplier performance monitoring
  - Reliability test ongoing:
    - IST – each new key technology part number (impact of design and stack up)
    - CAF – each new key technology part number (impact of design and stack up) ,
    - ATC – quarterly check,
    - Reflow & Solder reflow monitor – every lot check

# Methodology




STII = (Tg/2 + Td/2)- (CTE % x 10)
(solder temp impact index) per W. Engelmeier publication

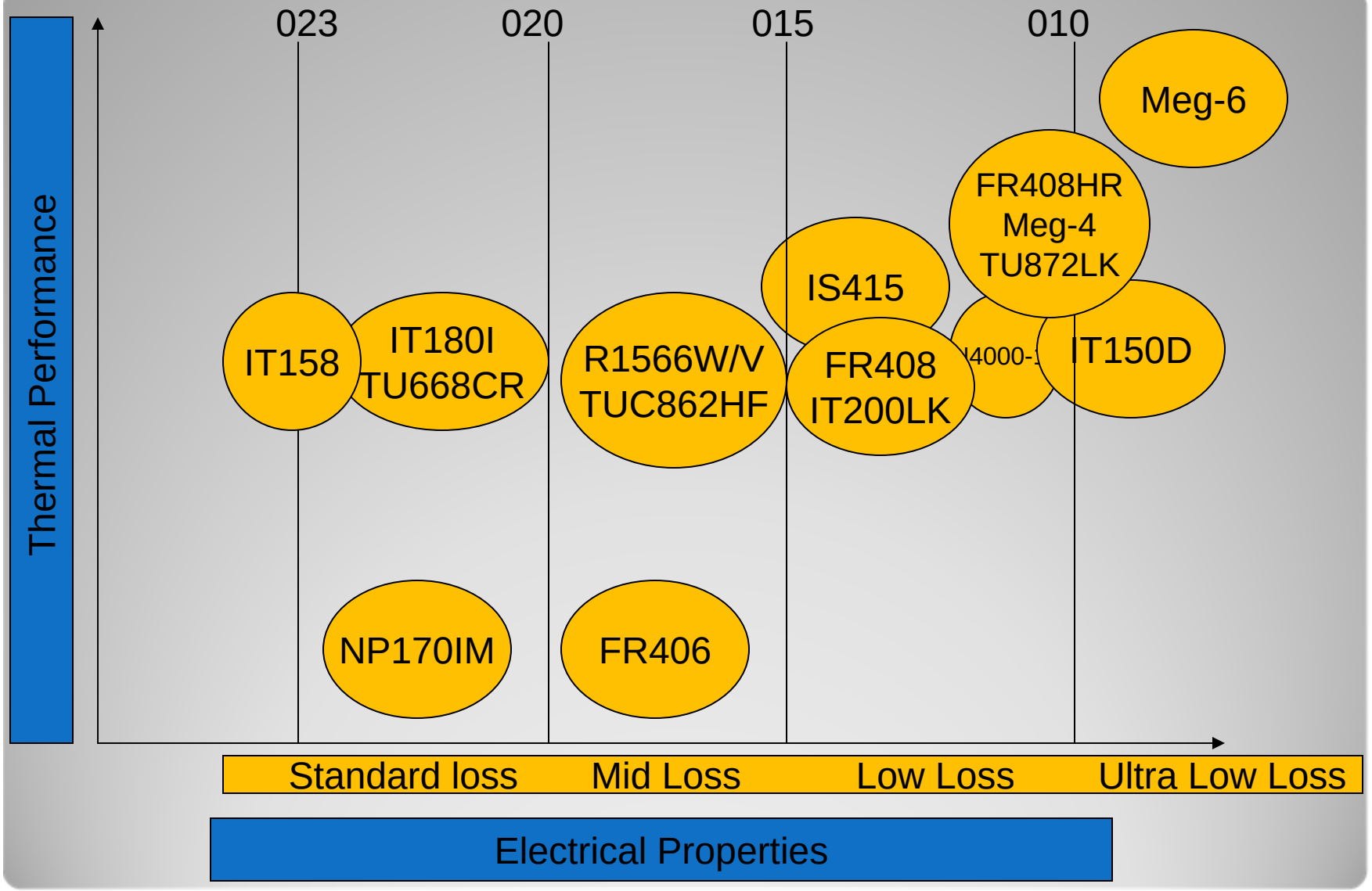
# Thermal –Tg, Td, STII

| Product ID | Df Low | Df High | Dk High | Dk Low | Tg | Td | T288 | STII Index | Filler | HF | CAF | ATC | IST* | Delam 245 | Delam 260 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R1755C | 0.0244 | 0.0269 | 5.188 | 4.171 | 176 | 360 | 30 | 251 | X | | NT | NT | | 6x | 6x |
| IT-158IM | 0.0218 | 0.0235 | 4.598 | 4.259 | 150 | 330 | >10 | 215 | | | 492 | 600 | 526 | 6x | 3x |
| TU668CR | 0.0216 | 0.0235 | 4.497 | 4.236 | 150 | 340 | >10 | 211 | X | | 504 | IW | 394 | 6x | IW |
| IT-180I | 0.0219 | 0.0229 | 4.832 | 4.596 | 175 | 340 | 2.8 | 230 | X | | 576 | 600 | 635 | 6x | 6x |
| EM-285 | 0.0191 | 0.0217 | 4.617 | 4.610 | 150 | 360 | 30 | 230 | X | X | 564 | NT | 783 | 6x | NT |
| R1566V | 0.0185 | 0.0195 | 4.828 | 4.330 | 148 | 370 | 12 | 229 | X | X | 444 | 600 | 491 | 5x | NT |
| EM-370D | 0.0178 | 0.0193 | 4.490 | 4.270 | 175 | 390 | >60 | 259 | X | X | NT | NT | | 6x | 6x |
| IT-170GR | 0.0171 | 0.0191 | 4.863 | 4.247 | 175 | 350 | >30 | 235 | X | X | 564 | NT | 867 | 6x | NT |
| EM-370 | 0.0177 | 0.0187 | 4.840 | 4.283 | 170 | 370 | >60 | 247 | X | X | NT | NT | | 6x | NT |
| NPGN-170 | 0.0172 | 0.0186 | 4.828 | 4.516 | 165 | 340 | >20 | 229 | X | X | 528 | NT | 493 | 6x | 6x |
| NPGN-150 | 0.0165 | 0.0183 | 4.641 | 4.320 | 145 | 340 | >20 | 213 | X | X | 552 | NT | 539 | 6x | 4x |
| IT-150G | 0.0171 | 0.0180 | 4.907 | 4.724 | 150 | 350 | >30 | 220 | X | X | NT | NT | | 5x | NT |
| IT-200LK | 0.0147 | 0.0165 | 4.259 | 3.523 | 200 | 350 | >30 | 251 | X | | 552 | 600 | 602 | 6x | 6x |
| TU862HF | 0.0137 | 0.0155 | 4.598 | 4.387 | 170 | 390 | >60 | 259 | X | X | 516 | 600 | 581 | 6x | 6x |
| IS-415 | 0.0132 | 0.0145 | 4.148 | 3.728 | 200 | 370 | 25 | 250 | X | | 540 | 600 | 482 | 6x | 6x |
| FR-408 | 0.0119 | 0.0135 | 4.071 | 3.797 | 180 | 355 | >20 | 233 | | | 552 | 600 | 558 | 6x | 6x |
| FR-408HR | 0.0097 | 0.0130 | 3.936 | 3.648 | 200 | 360 | >20 | 256 | X | | 588 | 600 | 617 | 6x | 6x |
| N4000-12 | 0.0091 | 0.0111 | 3.637 | 3.571 | 190 | 370 | >20 | 244 | | | 468 | NT | 509 | 6x | NT |
| TU872LK | 0.0102 | 0.0107 | 3.851 | 3.829 | 200 | 340 | 15 | 247 | X | | 536 | 600 | 580 | 6x | 6x |
| R5725 (Meg 4) | 0.0058 | 0.0088 | 4.679 | 4.885 | 175 | 360 | 30 | 251 | | | 600 | 600 | 872 | 6x | 6x |
| IT-150D | 0.0074 | 0.0084 | 3.768 | 3.443 | 150 | 340 | 15 | 211 | X | | NT | NT | | 6x | NT |
| R5775 (Meg 6) | 0.0038 | 0.0051 | 4.301 | 3.899 | 185 | 410 | >120 | 275 | X | | 900 | 900 | | 6x | 6x |

*5x 245C

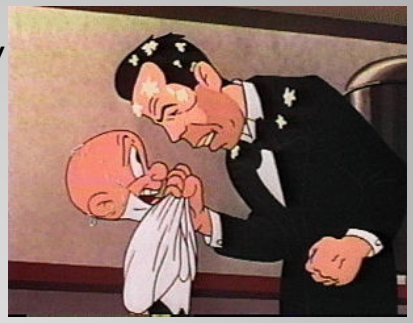
# Evolving Sweet Spot

GCE Gold Circuit Electronics


Thermal Performance
023
020
015
010
Meg-6
FR408HR
Meg-4
TU872LK
IS415
IT158
IT180I
TU668CR
R1566W/V
TUC862HF
FR408
IT200LK
IT150D
NP170IM
FR406
Standard loss
Mid Loss
Low Loss
Ultra Low Loss
Electrical Properties

- Cooperation with DfR Solutions. (design for reliability) HQ located in College Park Maryland with sites in China and Taiwan
  - 3 year relationship focuses on key material analysis, test and development concept

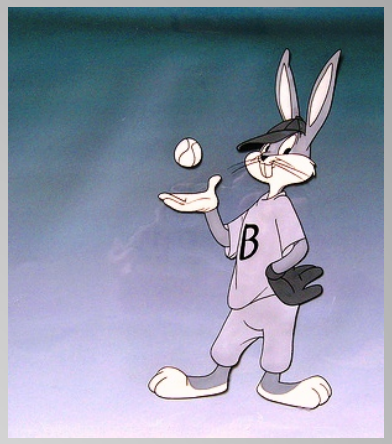
- Previous work (symposium posters)
  - CAF mechanisms and failure point analysis with increasingly narrow hole to hole spacing.
  - Use of capacitance testing to predict moisture levels and subsequent de-lam resistance in phenolic systems



- Current work (2009)
  - Assessment of fracture toughness and hardness as a predictor of post reflow thermo-mechanical behavior in mid Tg phenolic and halogen free systems

# PFMEA Testing

- Hardness and fracture toughness are characteristics that can change after thermal exposure
- Measurement of these features has been historically difficult
- "Ceramic" indenter method to record hardness but also potential for propagation of laminate crack analysis leading to a fracture toughness measurement.
- Next level of analysis to be completed this month



# Discussion

**Key Point summary:**

IBM methodologies are proven and effectively screen materials for electrical and thermal performance

Host of trade-offs desired require disciplined review of competing characteristics and test results.

- CAF, ATC, IST
- Df, Dk
- De-lam Resistance
- Hardness and Fracture Toughness

Pursuit of these additional methods like hardness and fracture toughness will be further useful for mass production readiness.