High Voltage Breakdown Levels in Various EPC Potting Materials

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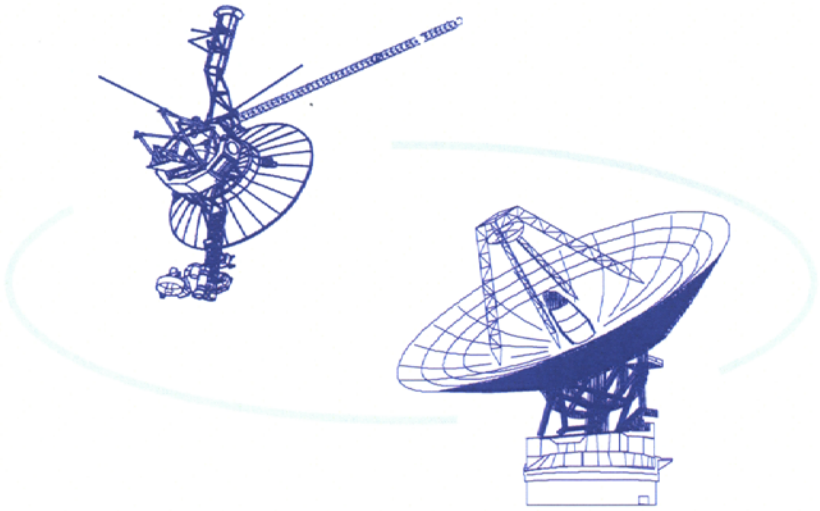


Introduction

- JPL flies radar transmitters on many missions
  - SARs and sounders obtain a variety of data
    - e.g., CloudSAT (scheduled to launch this month) carries 94 GHz radar to study clouds in upper atmosphere
  - These radars often use a vacuum tube operating at high voltage as the final amp
    - CloudSAT uses 18 kV EIK, SeaWinds had 8 kV TWT
- Pulsed HVPSs generally not available from industry
  - JPL forced to build pulsed HVPS in-house
- Large amount of mass tied up in HV insulation
  - Mass is always a premium resource on any spacecraft

∴ Explore less massive insulation methods

Current Potting Material

- Conathane® EN-11 (polyurethane) is the traditional HVPS encapsulant at JPL
  - Excellent adhesion, very tough, high tear strength
- But
  - Has max temp limit of only 135°; this temperature limit was insufficient during initial testing of CloudSAT radar
  - It has an awkward short pot life; viscosity doubles within 30 minutes of being mixed
- JPL started R&TD (i.e., IR&D) project to explore other encapsulants
  - Hence results reported here

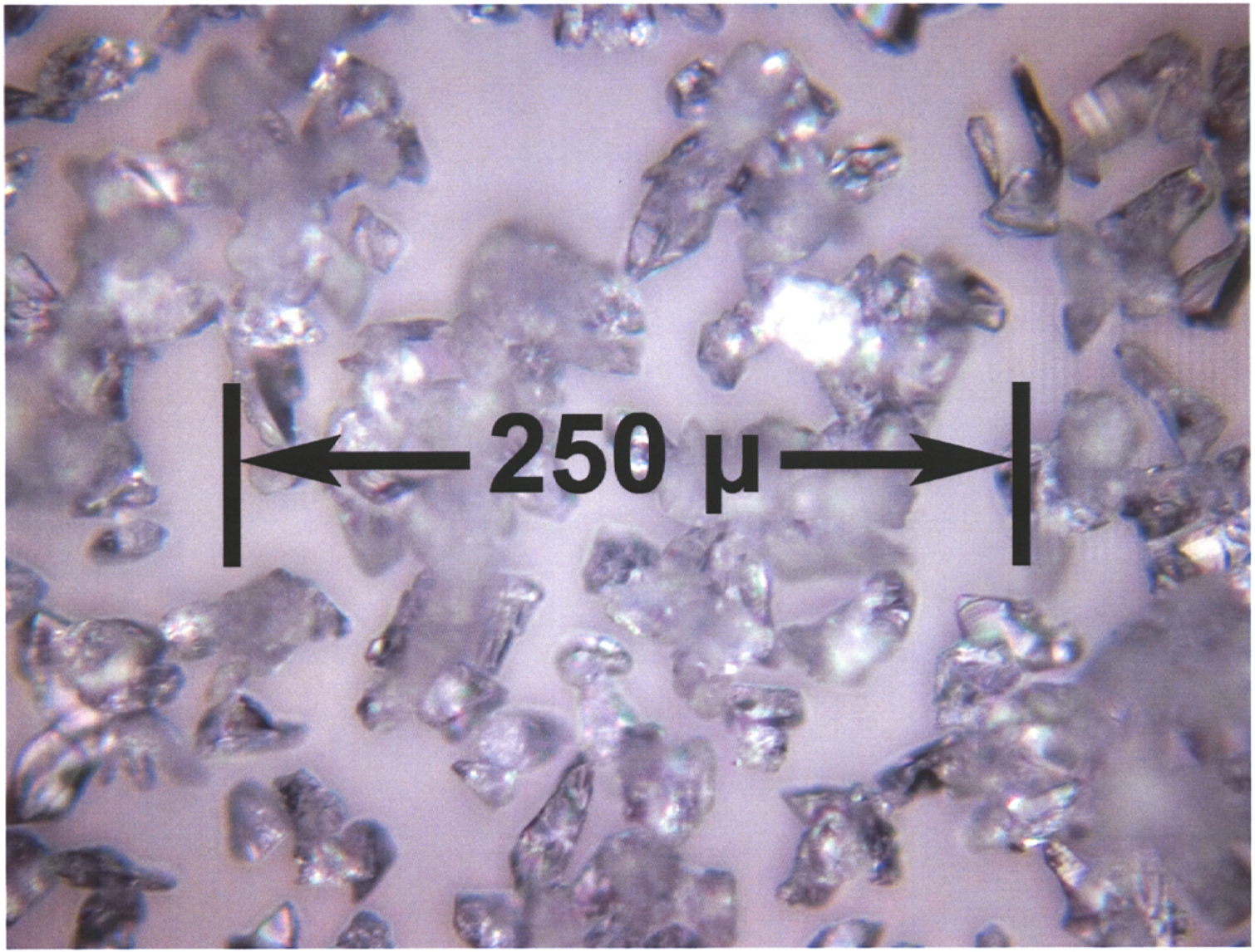
Other Possible Encapsulation Materials

- Epoxies
  - In general, too rigid for bulk encapsulation of HVPS
- Silicones – only other choice
- Two silicones especially formulated to meet outgassing requirements for space (ASTM E595-93e2): GE RTV566, and Dow Corning® 93-500
  - GE RTV566, and Dow Corning® 93-500
  - Dow Corning Sylgard® 184 can also meet outgassing requirements if cured properly
- Filler materials often added ("loaded") to potting compounds to alter final material properties

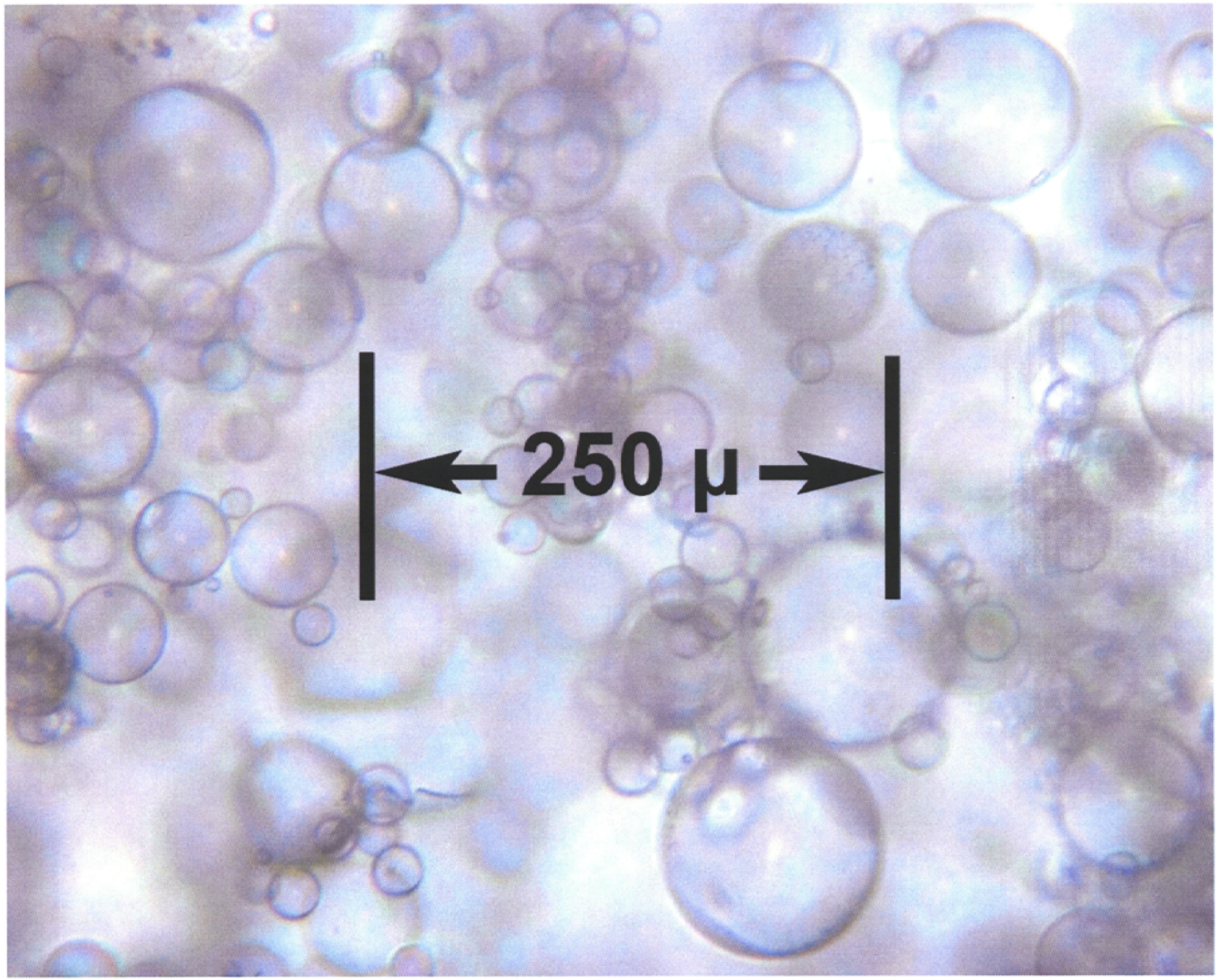
Filler Materials Investigated

- Alumina powder
  - Used to reduce the TCE of final compound
  - Increases density
  - Available as in either a "crystalline" form or in a somewhat amorphous spherical shape
- Borosilicate glass "microballoons"
  - Used to reduce the density of final compound
  - Available in a range of sizes

Crystalline Al_2O_3 Powder



Glass Microballoons



Potting Densities

Material and Loading (by weight %)	Density
EN-11	0.98
93-500	1.03
93-500 + 10% microballoons	0.78
93-500 + 20% microballoons	0.65
93-500 + 50% Al_2O_3	1.58

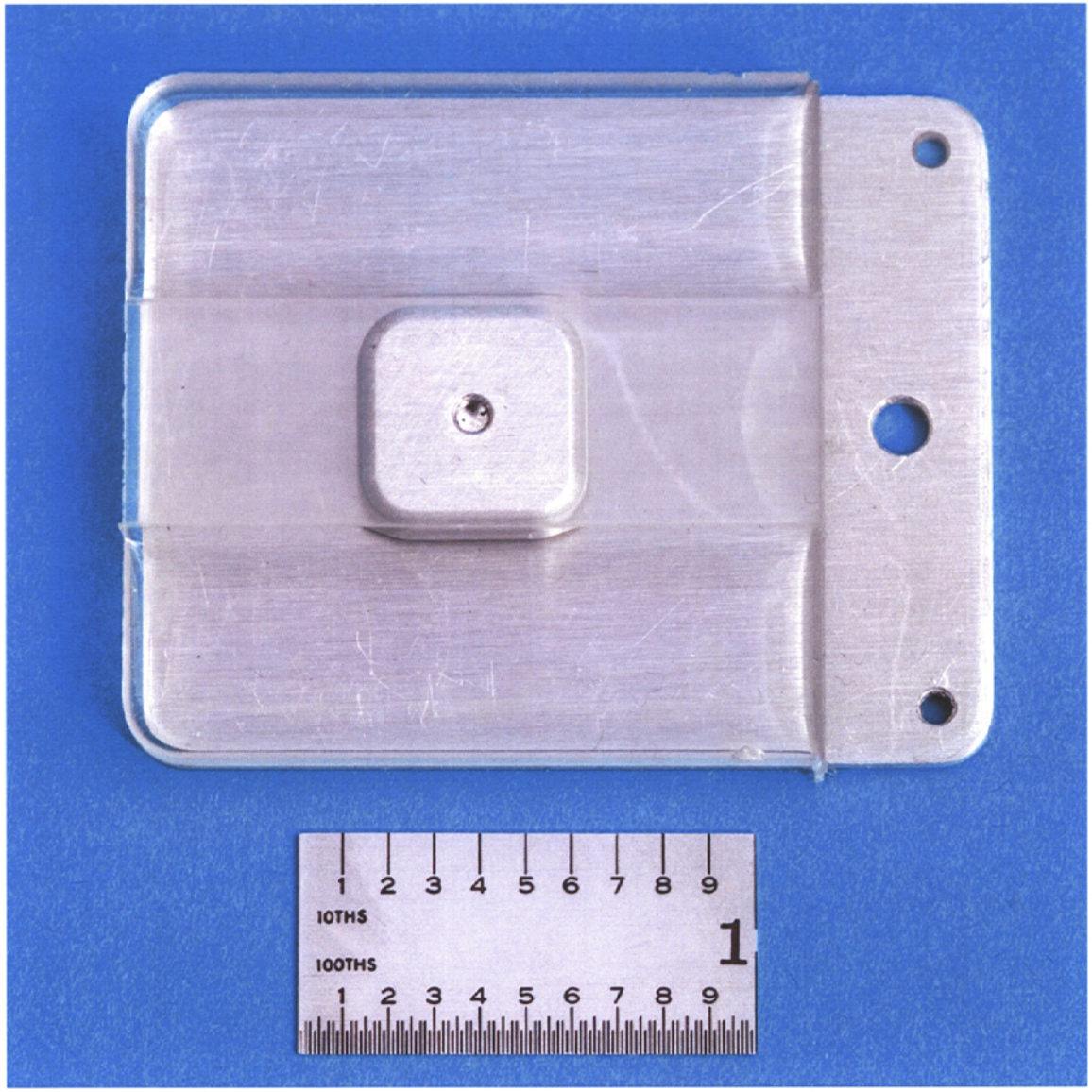
Electrical Testing

- Potting materials require various tests to determine suitability
  - Electrical characteristics of prime importance
- Corona inception voltage ("Biddle testing") and ultimate breakdown voltage selected
  - 60 Hz AC applied as compromise between DC and multi-kHz AC
- Standard test specimen developed
  - Useable with both polyurethane and silicone materials, both loaded and unloaded
  - Constant geometry except for electrode spacing

Test Regimen

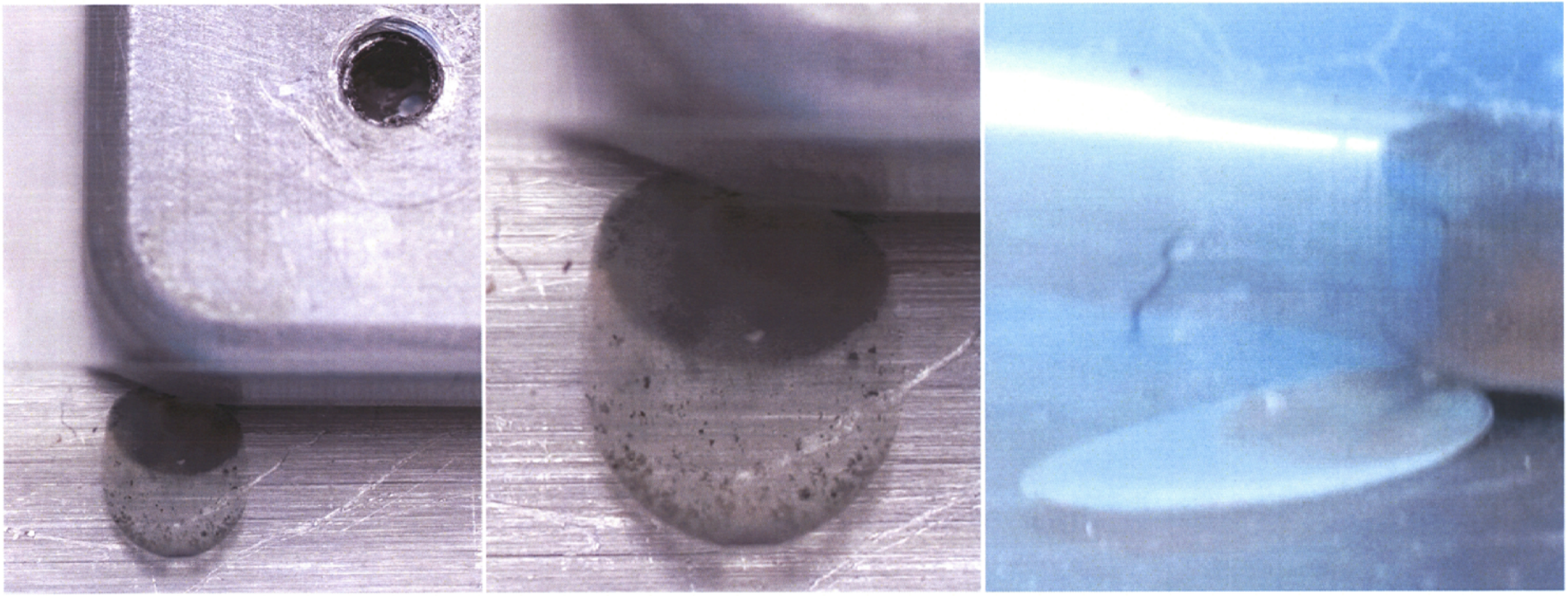
- Voltage applied to specimen via corona-free connection
  - Sample immersed in FC77
- Voltage slowly (over ~1-2 min) applied in steps of no more than 25%
  - Carefully observed for corona to catch CIV
- Sample maintained at least 1 hour at each step continuing observations
- Increasing voltage steps continued until breakdown occurred

Dielectric Test Sample

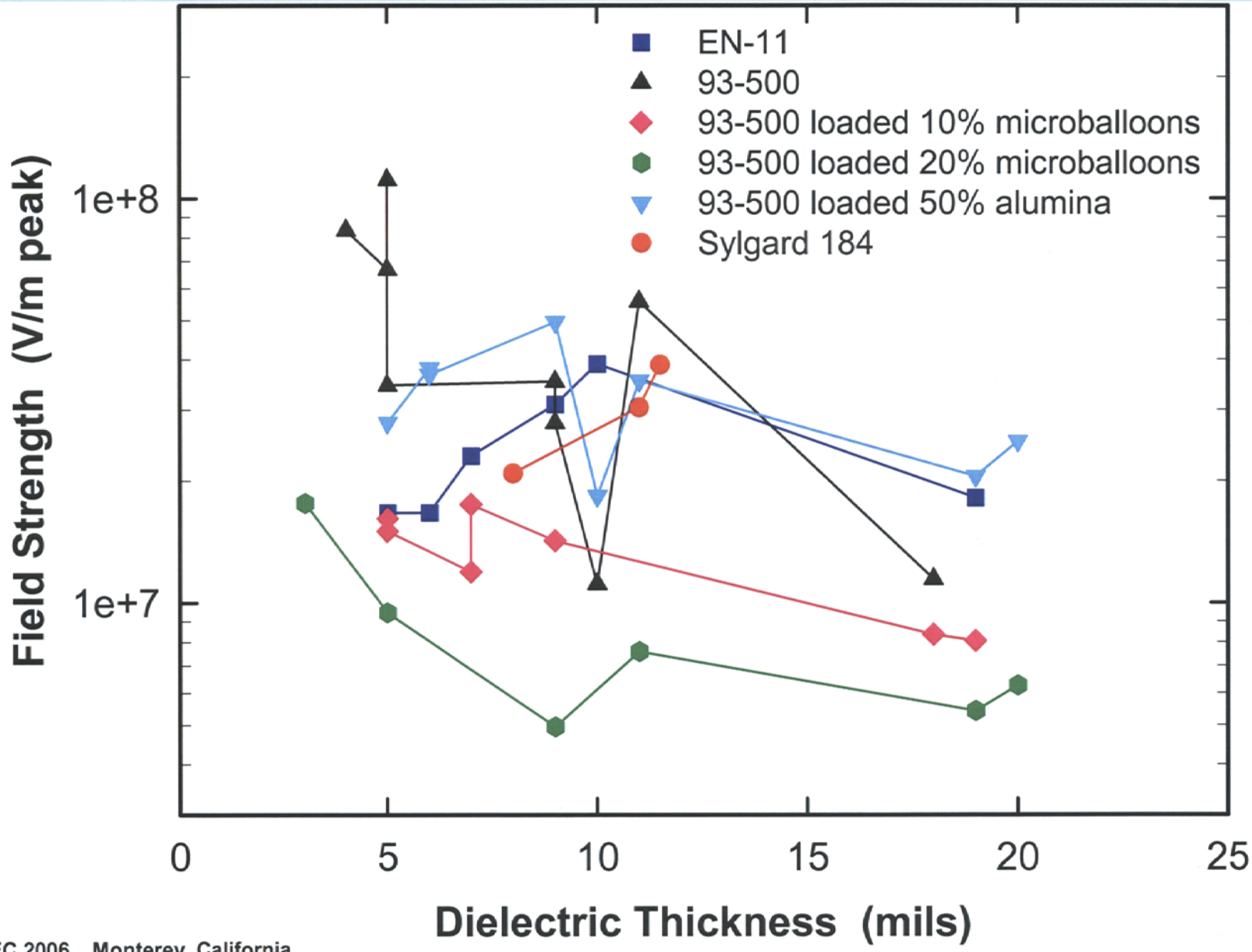


Sample in Test in FC77

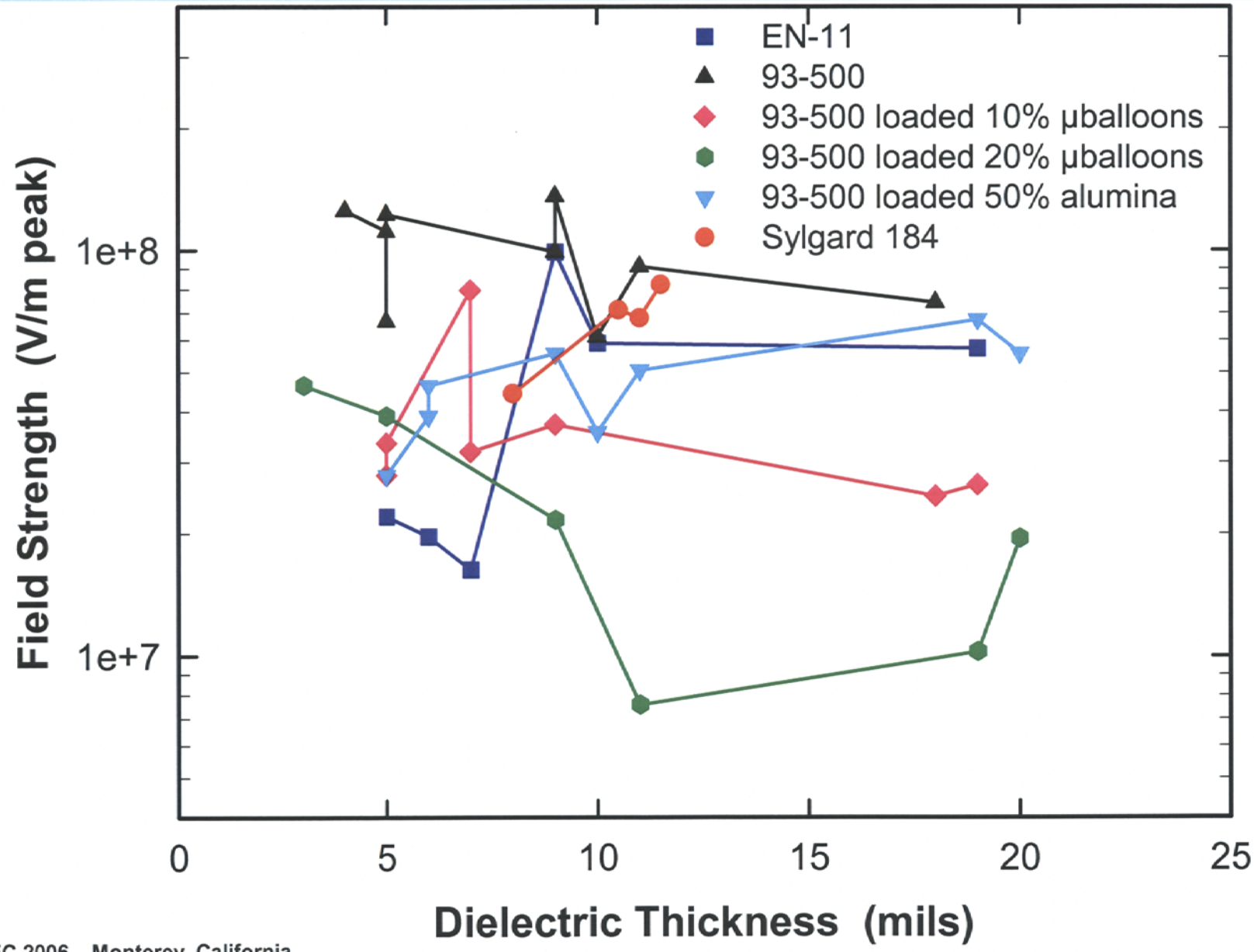
Failed Sample



AC Corona Inception Voltage (60Hz)



AC Breakdown Strength (60Hz)



Conclusion

- Large amount of scatter in data, but trends clear:
- Al_2O_3 loading electrically OK (but increases mass)
- Microballoons reduce electrical strength, but also reduce density of potting – careful trade required