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KAPTON PYROLYSIS, THE SPACE ENVIRONMENT AND WIRING REQUIREMENTS

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SPACE ENVIRONMENT WIRING
New LEO Requirements

- Atomic Oxygen Degradation Resistance
- Synergistic UV and AO Resistance
- Layout to Prevent Debris Strike Plasma Arc Flashovers
- Design to Prevent Plasma-Induced Pyrolysis
- AC Current Collection Issues

SPACE ENVIRONMENT WIRING
Traditional Requirements

- Wide Range of Operational Temperatures
- High UV and Radiation Resistance
- Sufficient Dielectric Strength
- Low Outgassing of Condensibles
- Low Mass per Unit Length

SPACE ENVIRONMENT WIRING
Kapton Pyrolysis in Vacuo

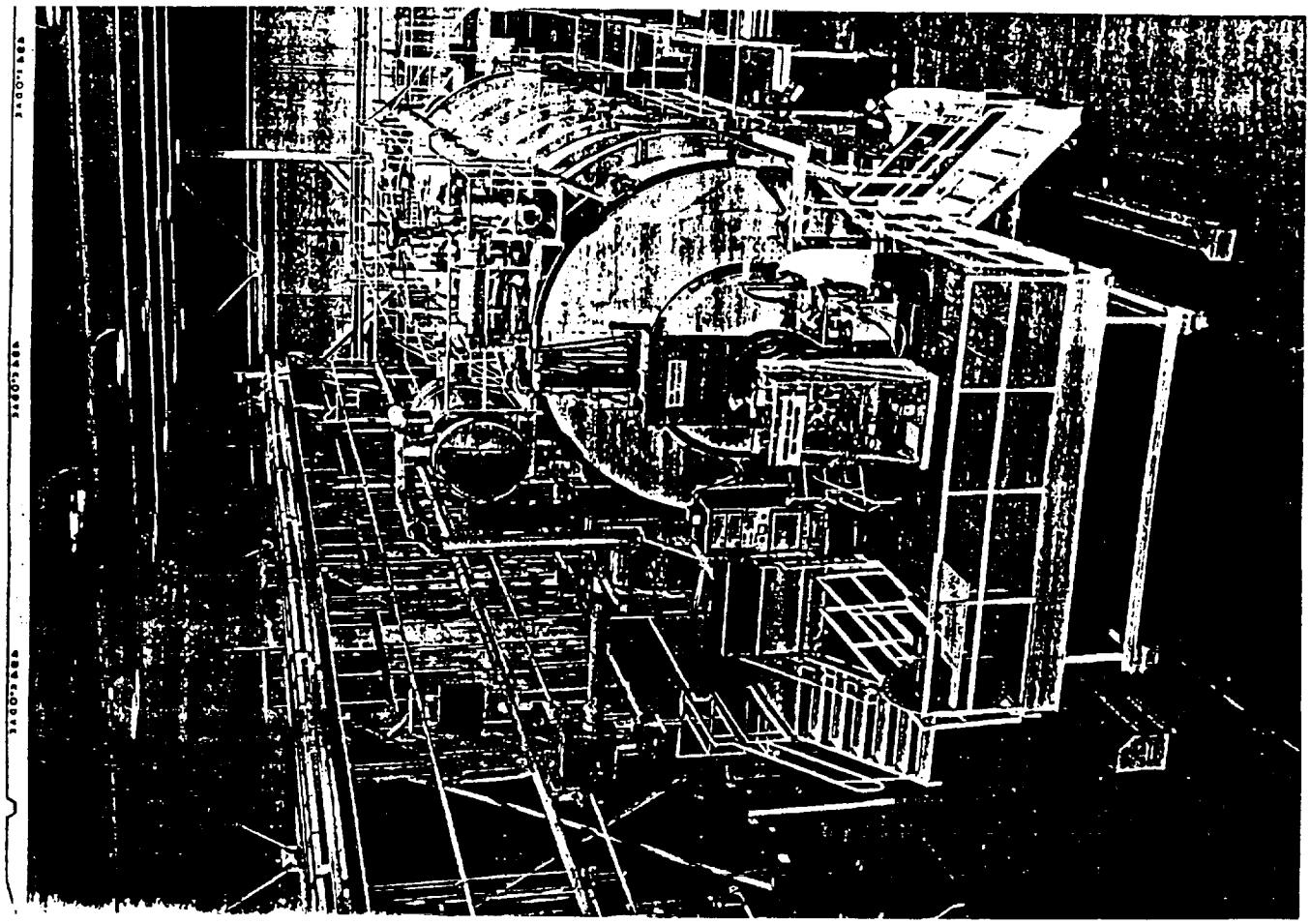
- Noticed in 1982 in LeRC chamber
  - moving point of light, carbonized trail
  - pressure less than one-ten-thousandth Torr
  - at edge of Kapton in high field
- Accidentally occurred in 1989 SSF Solar Array Plasma Test
  - small hole in Kapton over biased copper
  - electron collection current large
  - pyrolysis at hole edge
- Tests and Modeling at LeRC (1990, 91)
  - pyrolysis by electron current reproduced in vacuo
  - temperature behavior modeled
  - important parameters noted

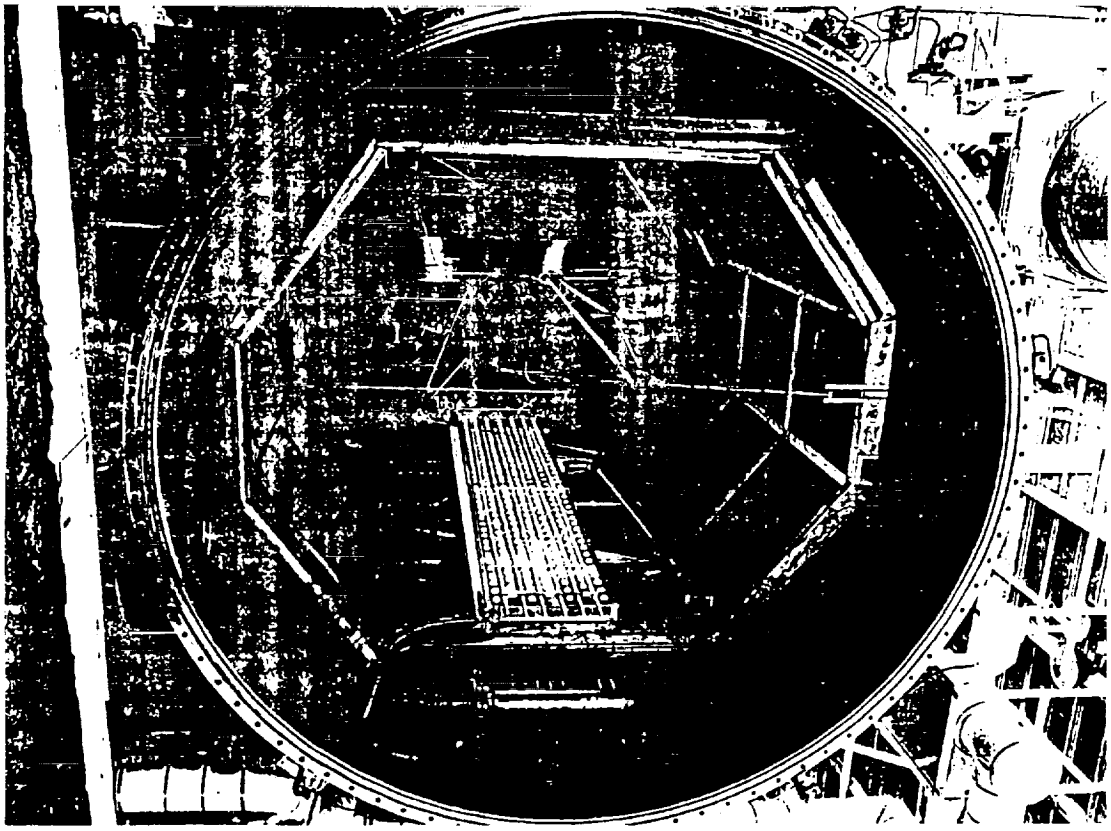
SPACE ENVIRONMENT WIRING
1982 LeRC Kapton Pyrolysis

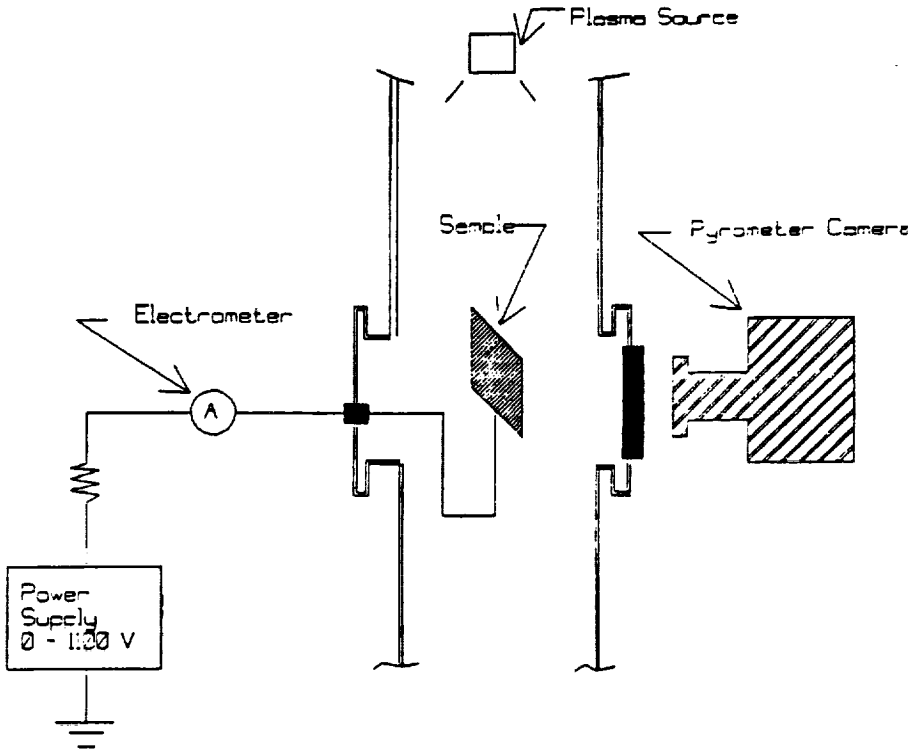
- Argon Ion Beam in LeRC chamber
  - 1000 V potential on acceleration grid
  - Argon ions created by microwave discharge
  - Kapton insulator for accel grid
  - Pressure 1/10 milliTorr
- Kapton Pyrolysis on Edge of 5 cm hole in Kapton
  - Pointlike, moving discharge
  - Continued for duration of voltage
  - Traversed entire circular edge
  - Entire edge charred, conductive
- Interesting Points
  - Required about 5 minutes before occurrence
  - No oxygen in chamber
  - Happened twice on different days

SPACE ENVIRONMENT WIRING
1989 SSF Kapton Pyrolysis

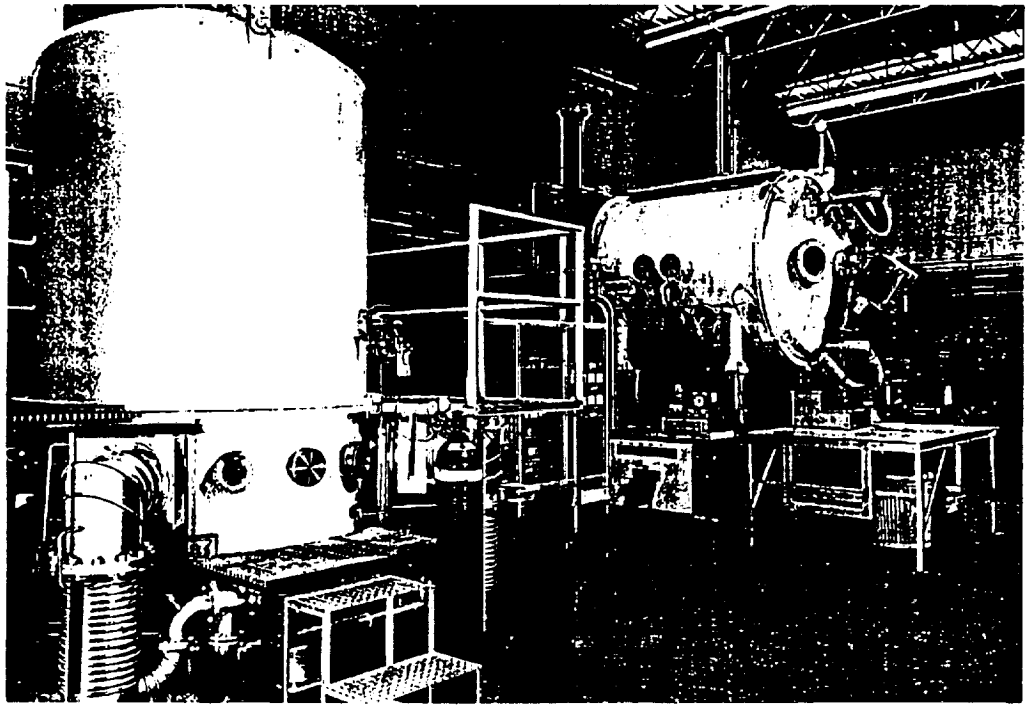
- Argon Plasma in Large LeRC chamber
  - +450 V potential on solar array panel
  - Argon plasma density 100,000 per cc
  - Small hole in Kapton over circuit trace
  - Pressure 1/100 milliTorr
- Kapton Pyrolysis on Edge of 1 cm hole in Kapton
  - No visual observation
  - Electron currents collected up by factor of 10
  - Charred Kapton-covered surface to edge of trace
  - Necessitated sample patching to continue tests
- Interesting Points
  - Happened after minutes in chamber
  - No oxygen in chamber
  - Metallization intact

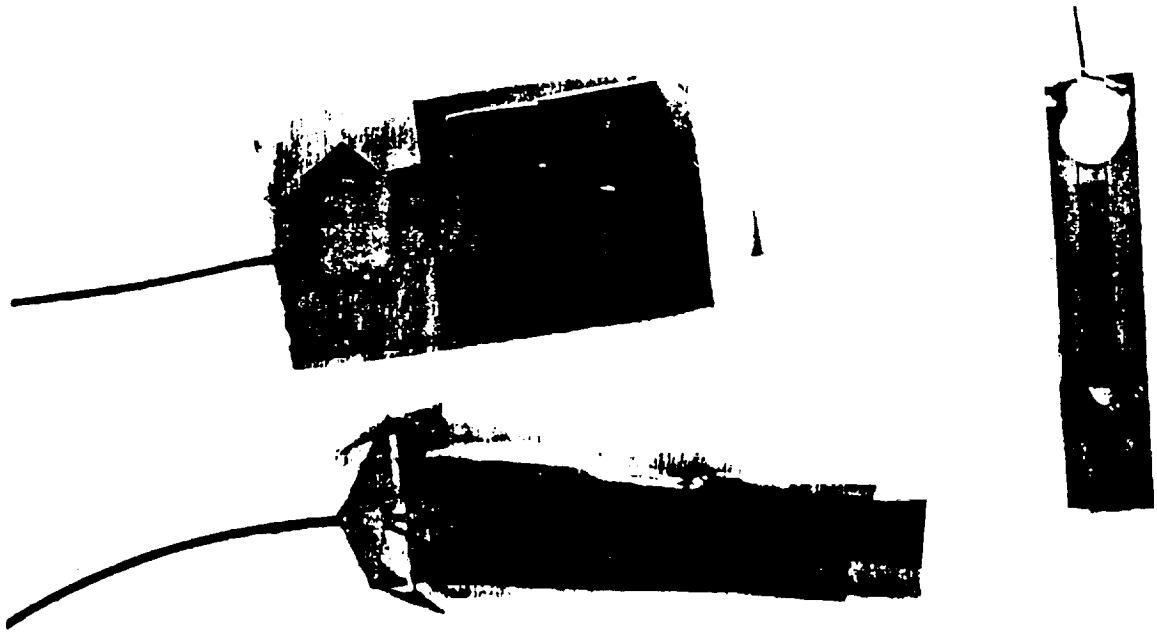






PYROLYZATION EXPERIMENT SETUP

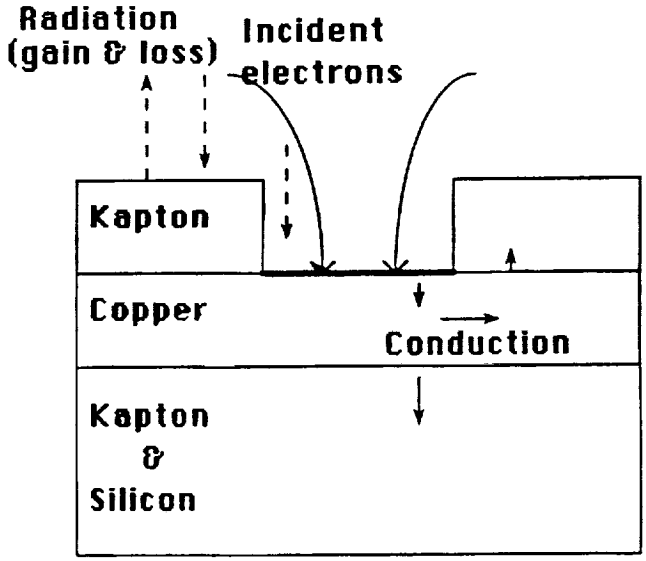




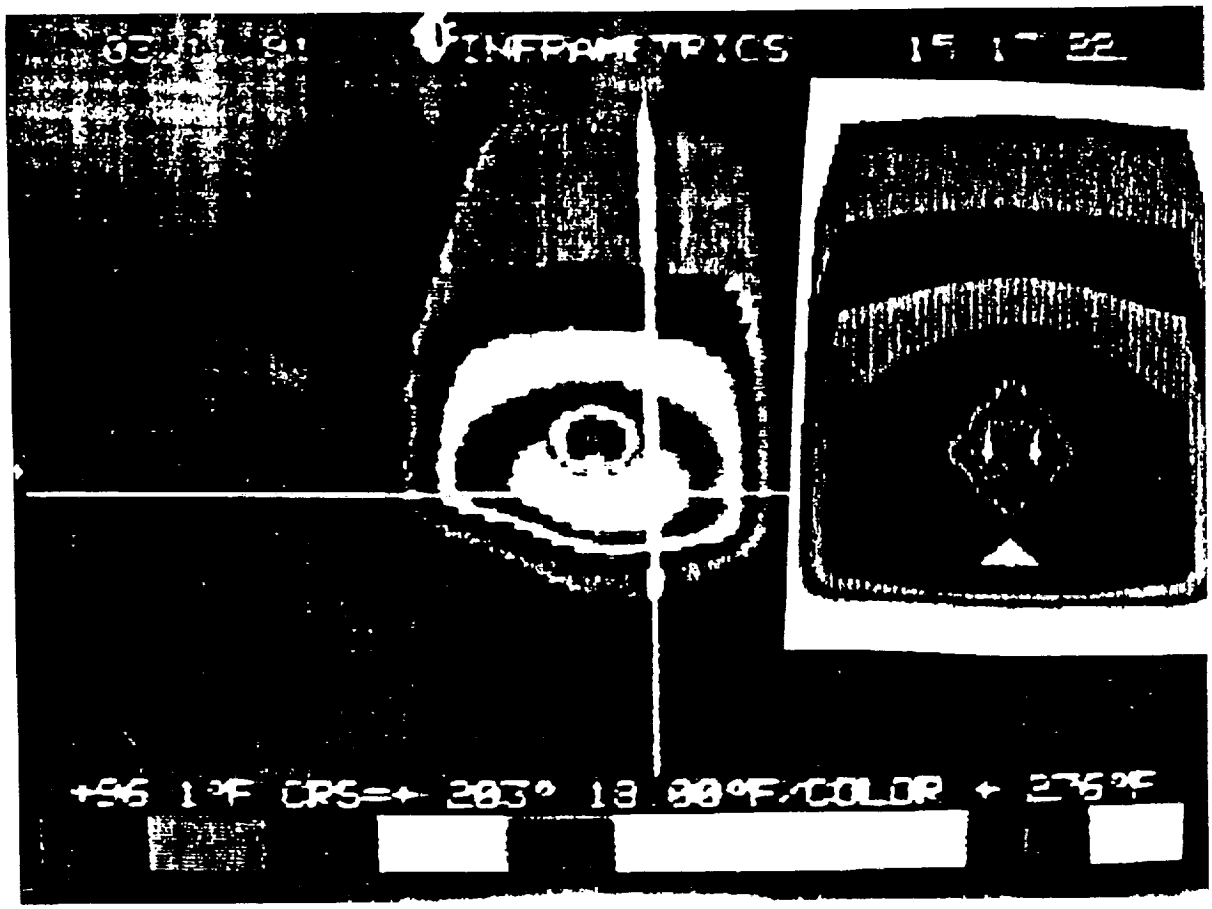
SPACE ENVIRONMENT WIRING

SEEB Modeling of Kapton Pyrolysis

- Kapton Pyrolysis Assumed to be Temperature Effect
  - Positive Bias for Electron Collection
  - Current times Voltage = Power into Heating Conductor
  - Conductor heats overlying Kapton
  - All sources and sinks accounted for
- Model Predicts Temperatures Observed in Tank Tests
  - Ohmic heating of current traces important
  - Trace thickness, width important to conduction
  - Kapton thickness, hole size important
  - Kapton adhesives, outgassing may be important
- Interesting Points
  - Pyrolysis occurs at 200-300 C, well below char temp
  - Hypothesized set of conditions for occurrence
  - May be designed around



Sverdrup Technology



KAPTON PYROLYSIS

Hypothesized Conditions for Occurrence

- The current carrying trace is thin and covered all over with a poor heat conductor.
- The Kapton insulator covering the trace has a hole large enough to prevent current chokeoff (› 60 mil) but small enough to collect high snapover currents (‹ 1 inch?).
- The conductive trace is exposed to a high density LEO plasma in the ram direction.
- The trace is above + 100 V with respect to the LEO plasma.
- All the above conditions hold for › 10 seconds.