A Robust Planar Triggered Sparkgap Switch for High Power Pulse Applications

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Chip Slapper Detonator
Typical Capacitor Discharge Unit (CDU)
Switch Requirements

- Standoff voltage greater than 1500V

- Switch should allow fast discharge of a high voltage capacitor with a discharge time ($\tau$) less than 100 ns.

- The switch should be capable of being actuated with a low voltage signal (i.e. <50V trigger pulse).

- Fabrication should employ a simple layout that allows direct integration into strip-line geometries (minimize parasitic impedances).

- Monolithic construction should be employed using conventional micro-electronic fabrication techniques to make the switch mechanically robust.

- No energetic compounds can be used in the construction of the switch.
Planar Triggered Spark-Gap Switch
Switch Actuation

Dielectric

Initial Ionization

Slapper

Detonator

HV Capacitor
Switch Actuation

- Ceramic Substrate
- Copper
- Copper
- Trigger Electrode
- Plasma Discharge
- Initial Ionization
- Slapper Detonator
- High Voltage Capacitor
Ring Down (PTS Switch) C=.17uF, V=1000V, Test Load = .004ohm
Parylene Shock Switch

- Schottky barrier trigger
- Top electrode (-) (Ti, W, Ti, Cu, Au)
- Bottom electrode (+) (Cu, W)
- Kapton film
- Parylene film
- Alumina substrate
Schematic representation of shock switch.
Schematic representation of switch actuation.

Closed switch (i.e. FET)

Plasma burst

Metal
Parylene (dielectric)
Metal: Cu/W
Ti/W/Ti/Cu/Au

Kapton film

2 mF Low voltage capacitor

50V

(800V-1000V)

0.3 µF High voltage capacitor
High voltage switch firing data obtained from a high speed digital oscilloscope. Traces are shown for the capacitor voltage, switch voltage, and switch current.
Planar Discharge Switch (PDS)
Fired Planar Discharge Switch
Miniature Fireset Concept with Planar Discharge Switch

- Electrical Contact A
- Electrical Contact B
- Electrical Contact C
- Polyimide Layer
- PDS Switch
- Tungsten Coating
- Copper Trace
- Polyimide Layer
- Copper Bow-Tie Bridge
- Plated Through-Hole Connection
- Ceramic Substrate
- SMT FET
- SMT Capacitor
- Underfill

Dimensions:
- 0.4" in vertical direction
- 0.5" in horizontal direction
PDS plus EFI with Common Substrate

Switch area

EFI

400 mils
First level is patterned aluminum, bridge is standard size

Switch area

EFI Bridge
Zoomed view of “switch area”

small bridges are 2.5mil x 2.5mil
Liftoff layer for coating aluminum with Ti/Cu/Au

Switch Area
Expanded view of switch overcoat, gaps are ~15um, copper covers everything except Al bridges.
Blue is aluminum, orange is aluminum coated with Ti/Cu/Au
Polyimide layer
Switch after Ti/Cu/Au and Polyimide
Hi Voltage Stressing indicates standoff voltage ~ 4kV
68 die on typical 4 inch substrate
Ring Down (PDS Switch)

$C=0.2\mu F$, $Voltage=800$, $Test\ Load=0.004$
Jitter is repeatable and acceptable for typical EFI applications
Present Work
Reduce Size/Integrate on Standard Header
Conclusion

A novel one-shot switch has been introduced.

The structure is simple to construct using standard microelectronic processing techniques.

The device is easily integrated into flat stripline geometries

Device successfully functioned slapper with HNSIV