Packaging Technologies for Power Electronics

INNOVATION

QUALITY

EFFICIENCY

RELIABILITY

Presentation Summary

- WHO ARE DYNEX
- MARKETS & PRODUCTS
- RELIABILITY ISSUES & TECHNOLOGY IMPROVEMENTS
- CURRENT STATUS & FUTURE PLANS

Dynex Heritage

Alstom D.R.E

Plessey Semiconductors 1961

Silec 1960

SGS Thomson Power Division - France 1979

Sescosem 1970

Marconi Electronic Devices 1981

GEC Plessey Semiconductors 1990

Mitel Semiconductor 1998

DYNEX SEMICONDUCTOR 2000

TEG 2008

Marconi Elliot 1960

GEC Semiconductors 1963

AEI Electronic Apparatus Division 1959

AEI Semiconductors 1963

BRITISH THOMSON HOUSTON ESTABLISHED OPERATION IN LINCOLN 1956

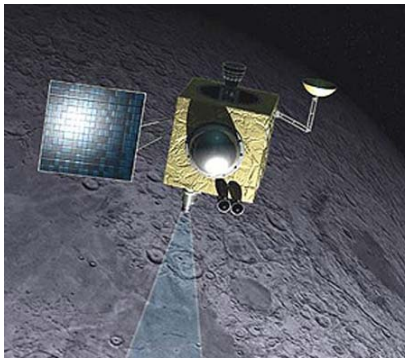
1963 - First UK fully diffused thyristors produced at Lincoln

9,000m^2 design, development, manufacture, and engineering support facility located at Doddington Road Lincoln
Staff : 250

HIGH POWER SEMICONDUCTORS

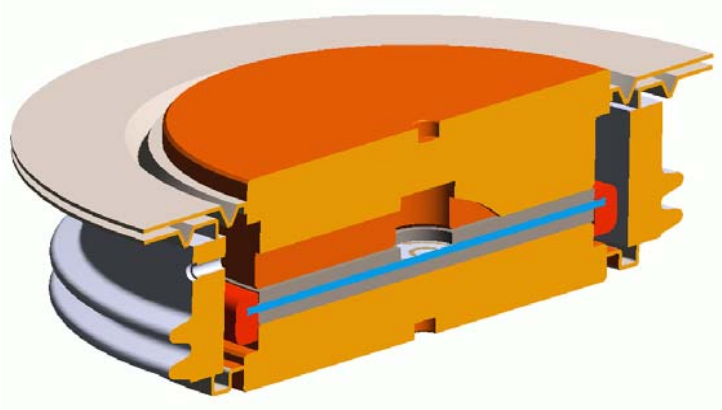
MARKETS

- Electric Power Transmission and Distribution
- Renewable and distributed Power
- Marine and Rail transportation
- Heavy engineering i.e. Steel & mining
- Aerospace
- Medical equipment
- Telecommunications
- Electric Vehicles



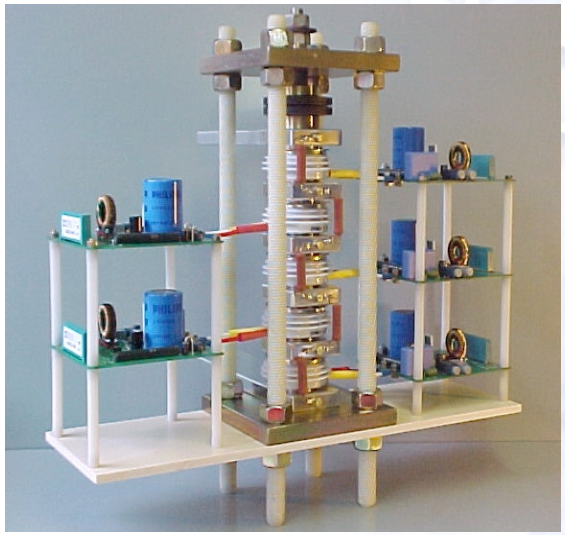
PRODUCT GROUPS

BIPOLAR



MODULE

POWER ASSEMBLIES



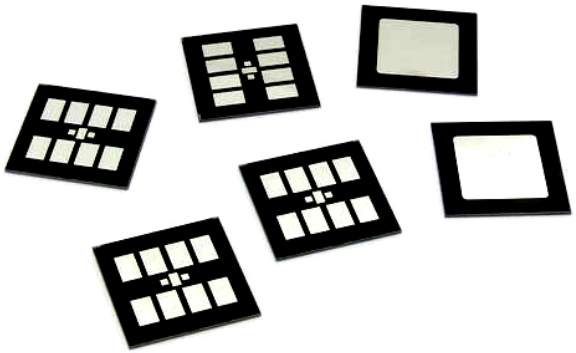
SILICON ON SAPPHIRE

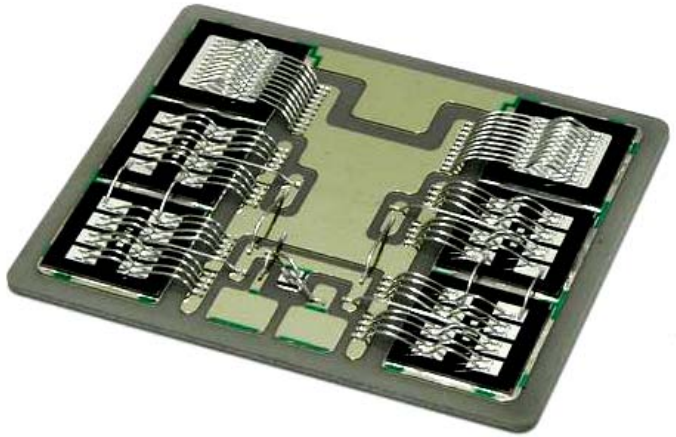
PRODUCT GROUPS

IGBTs
SCRs
GTOs
iodes
semblies

Focus on IGBT Plastic module

PRODUCTS - IGBT MODULES





IGBT MODULES - MISSION PROFILE FOR RAIL TRACTION


MASS TRANSIT

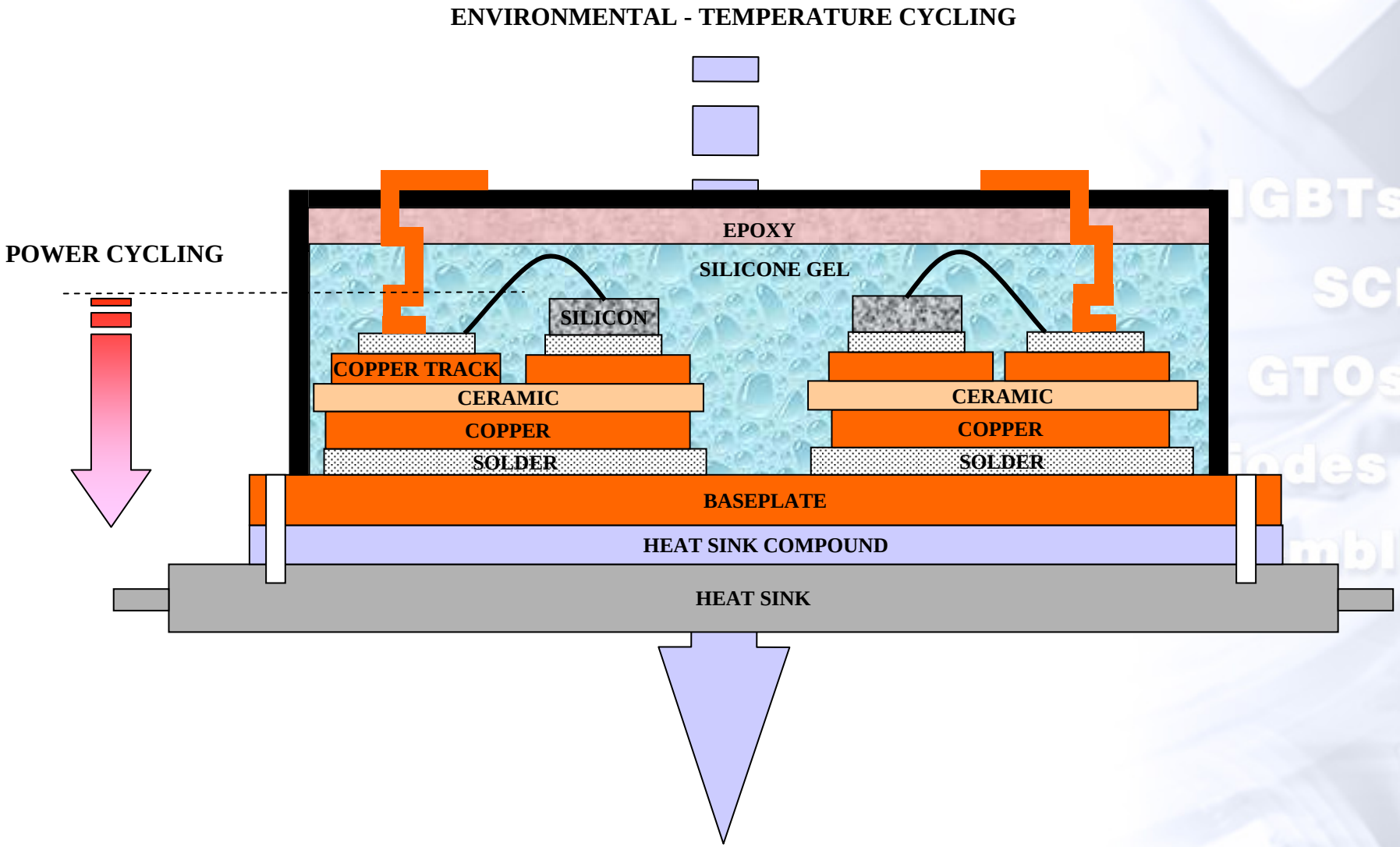

HIGH SPEED

TYPICAL 3O YEAR LIFE

SHED STOPS: 30 * 350 = ~ 10,000 Cycles
STATION STOPS : 30 * 350 * 18 * 30per hour = ~ 5,670,000 Cycles
POWER CYCLES: (1KHz): 30*350*18*60*60*1000 = ~ 7E11 Cycles

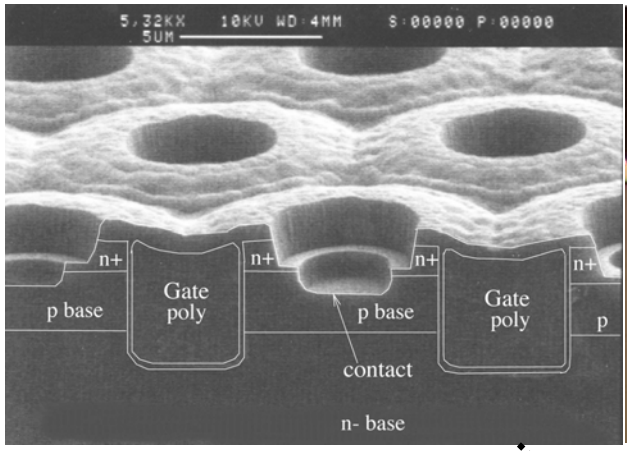
SHED STOPS: 30 * 350 = ~ 10,000 Cycles
STATION STOPS : 30 * 350 * 18 * 2per hour = ~ 378,000 Cycles
TRACTION/BREAKING: 30*350*18*60*3per min = ~ 34,000,000 Cycles
POWER CYCLES: (1KHz): 30*350*18*60*60*1000 = ~ 7E11 Cycles

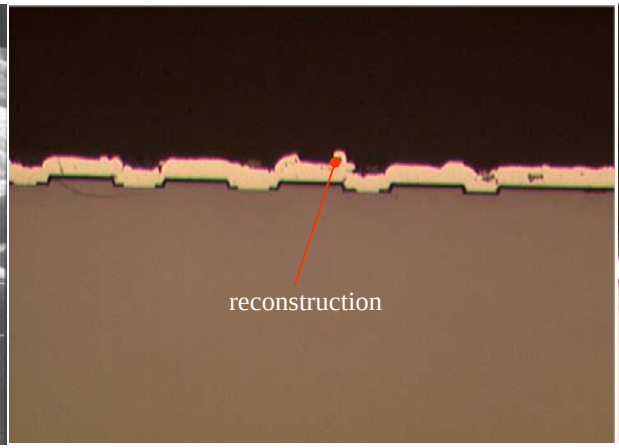
IGBT MODULES SCHEMATIC

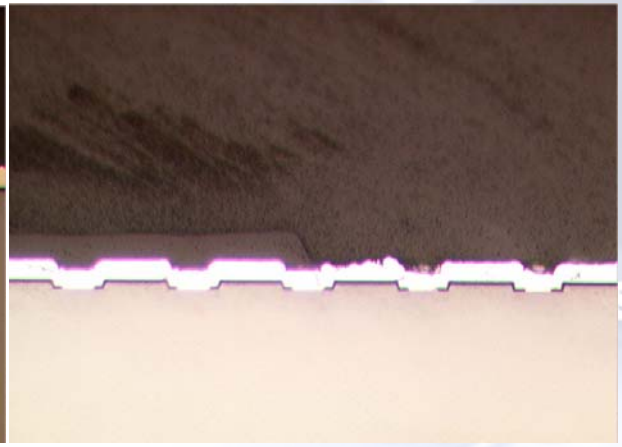


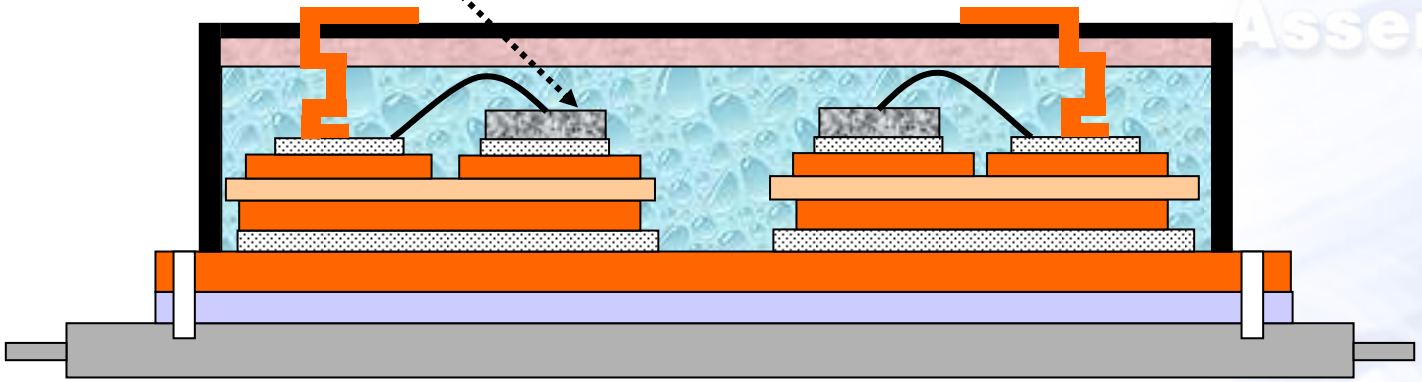
WEAR OUT MECHANISMS : ALUMINIUM METALLISATION

SOLUTION

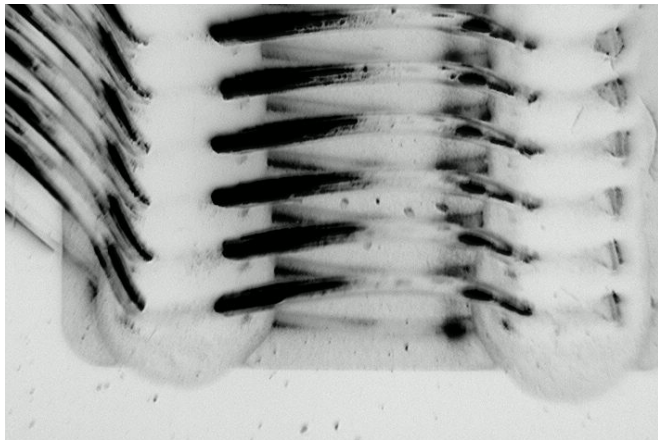


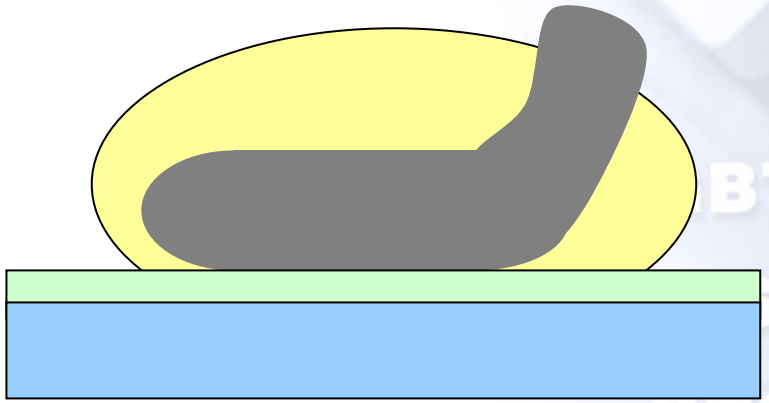


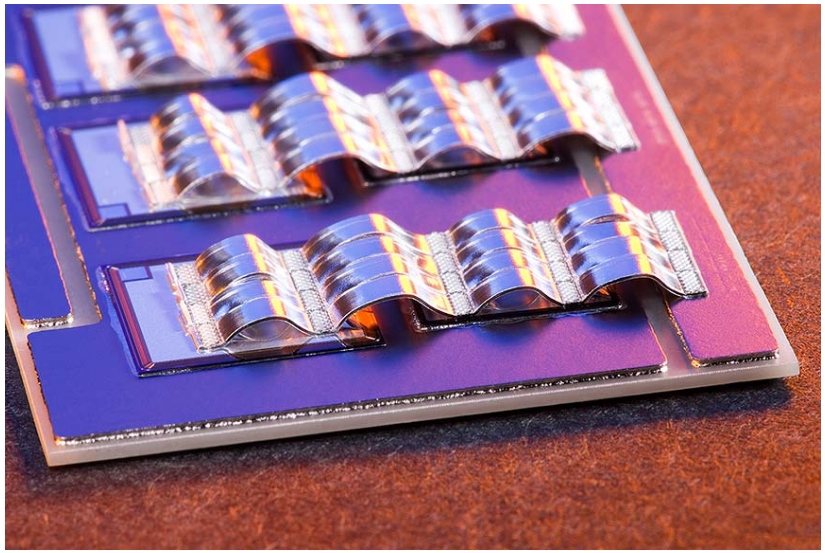


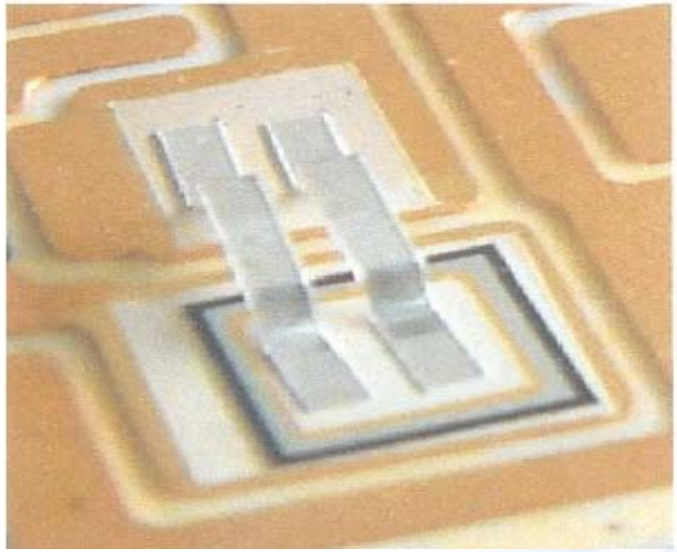


WEAR OUT MECHANISMS : WIRE BOND - Solutions

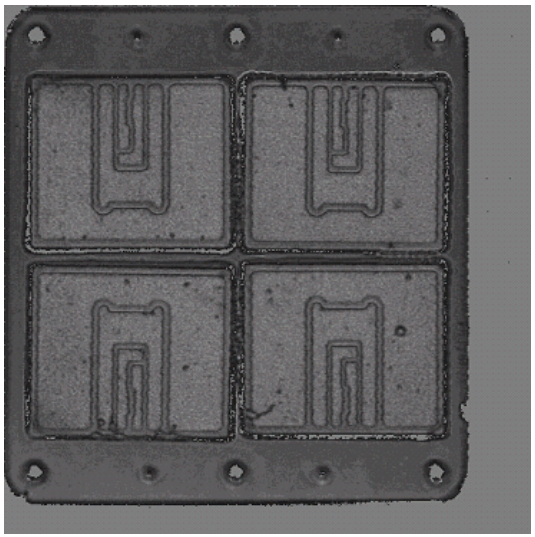


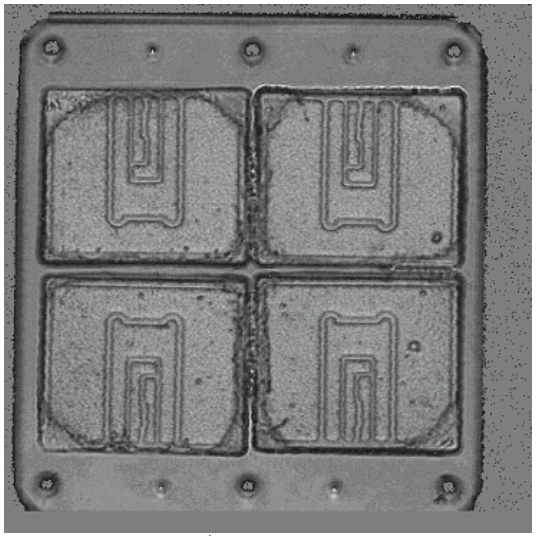


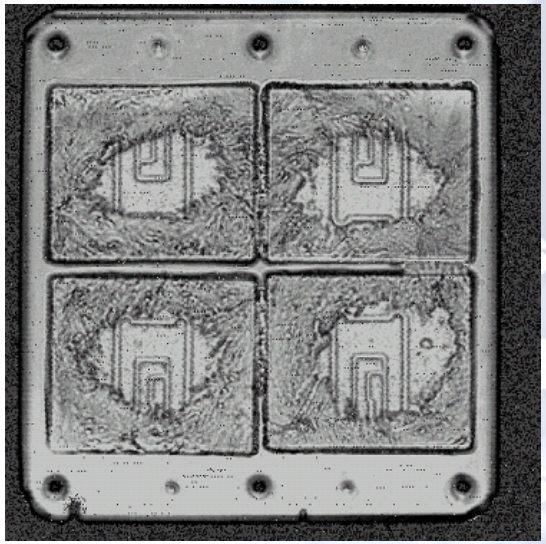


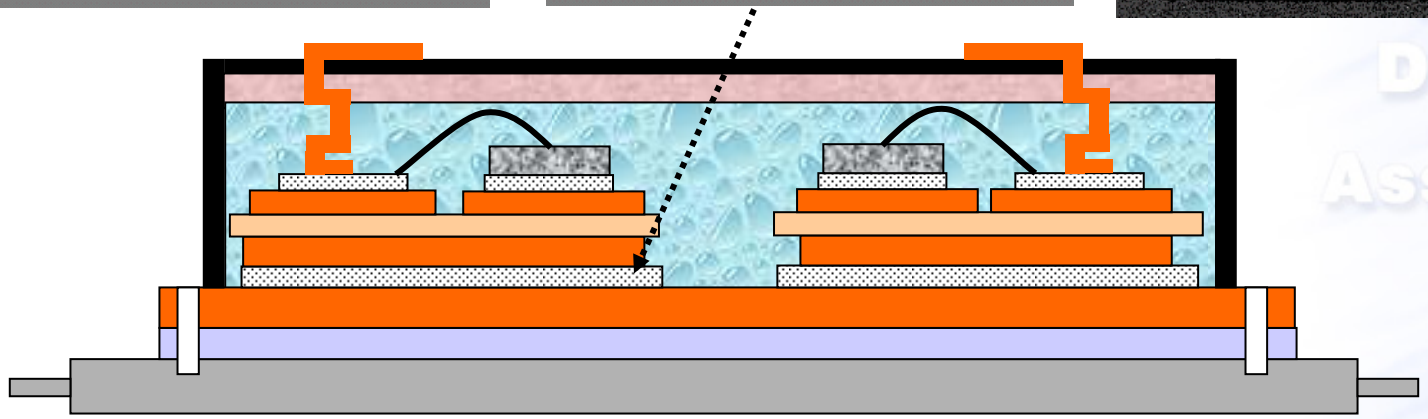


WEAR OUT MECHANISMS : SUBSTRATE SOLDER







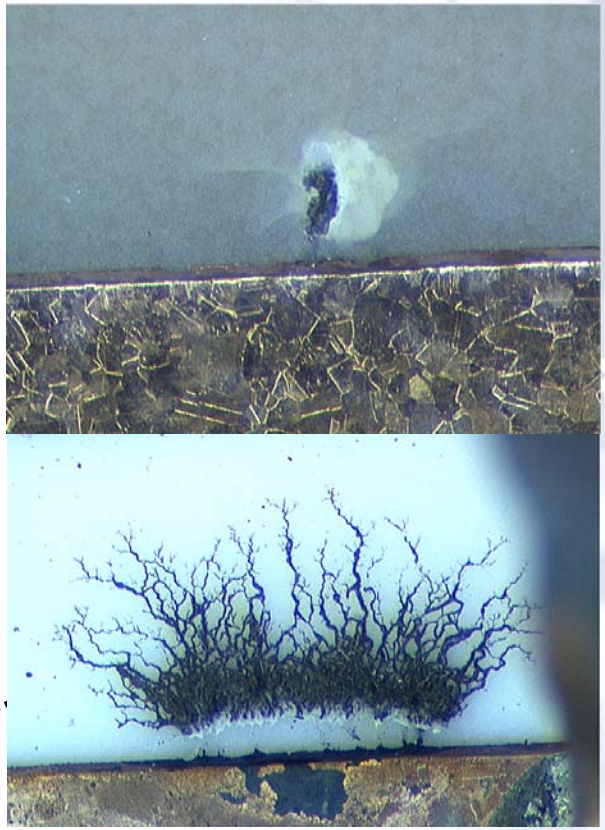


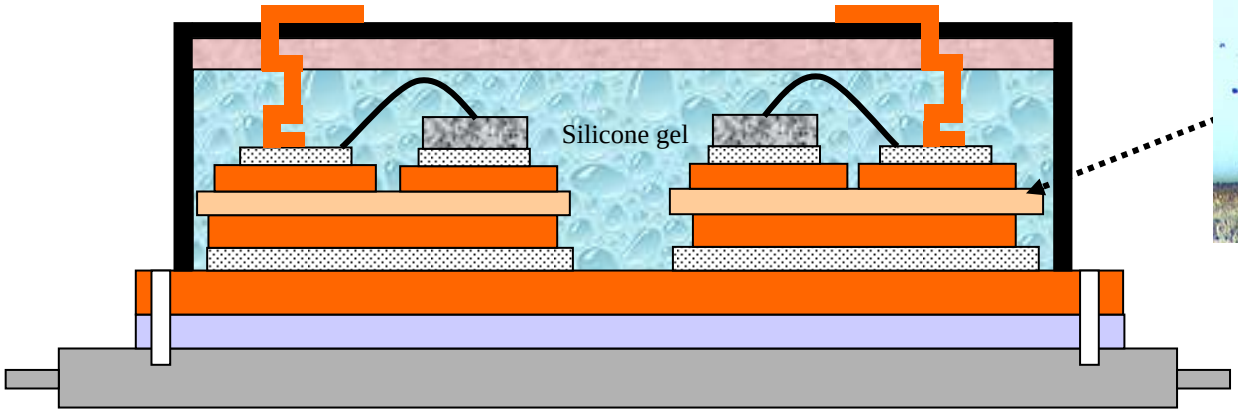
SOLUTION

1. Reduce thermal mismatch : Copper / Al2O3 8,000 cycles > AlSiC / AlN 30,000 + Cycles (delta T - 80`C)

WEAR OUT MECHANISM : ENCAPSULATION - SOLUTIONS

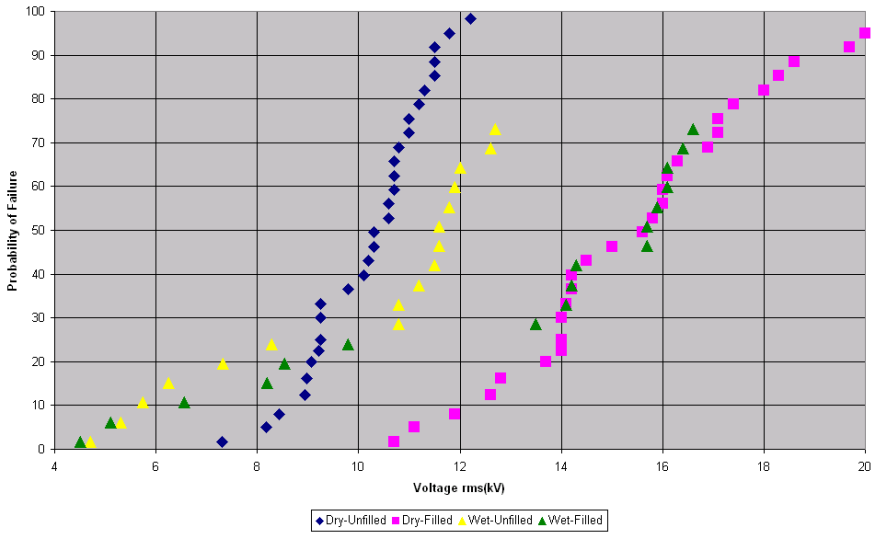
- Partial Discharge





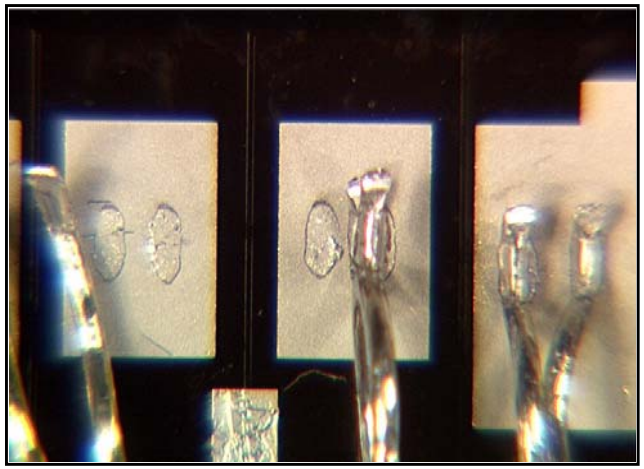
WEAR OUT MECHANISM : ENCAPSULATION - SOLUTIONS

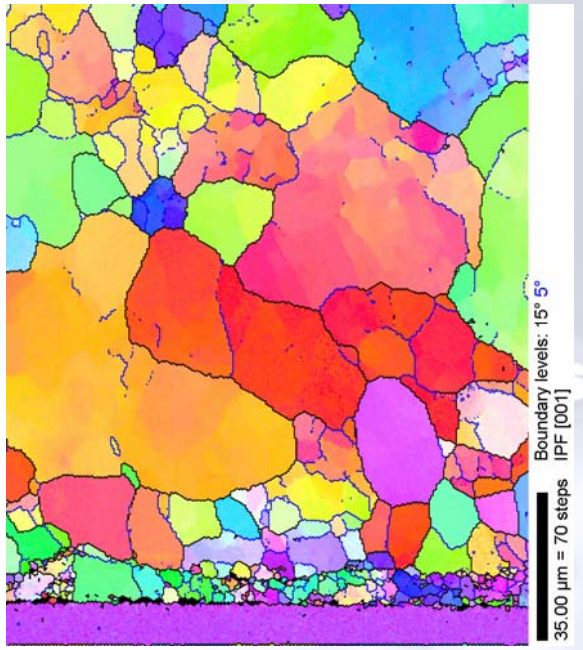
- PROCESS CONTROL
  - Cleanliness
  - Mixing
  - No presence of curing inhibitors

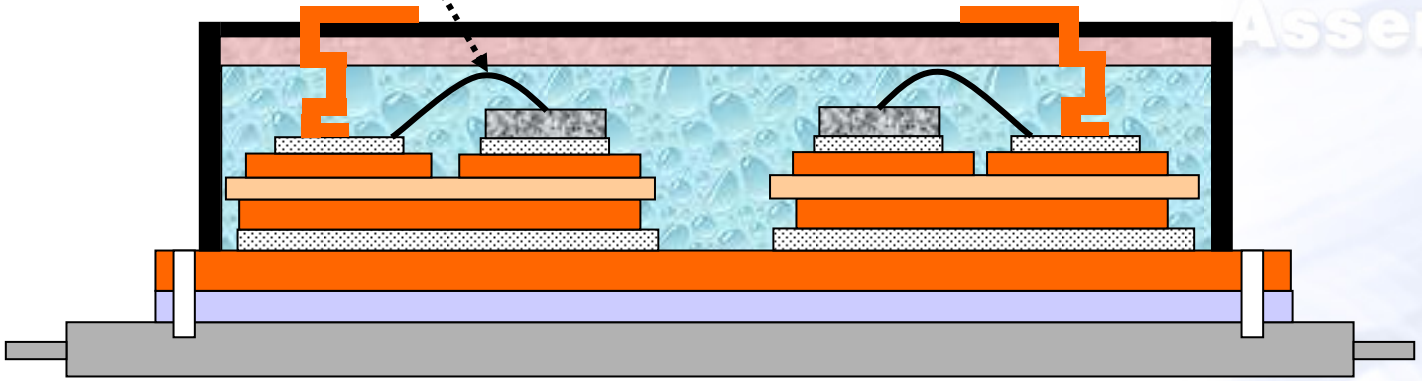


- TECHNOLOGY CHANGE
  - Ferroelectric filler
    - Silicone gel having a permittivity that increases as a function of local electric field
    - An elevated local permittivity produces a lower local electric field

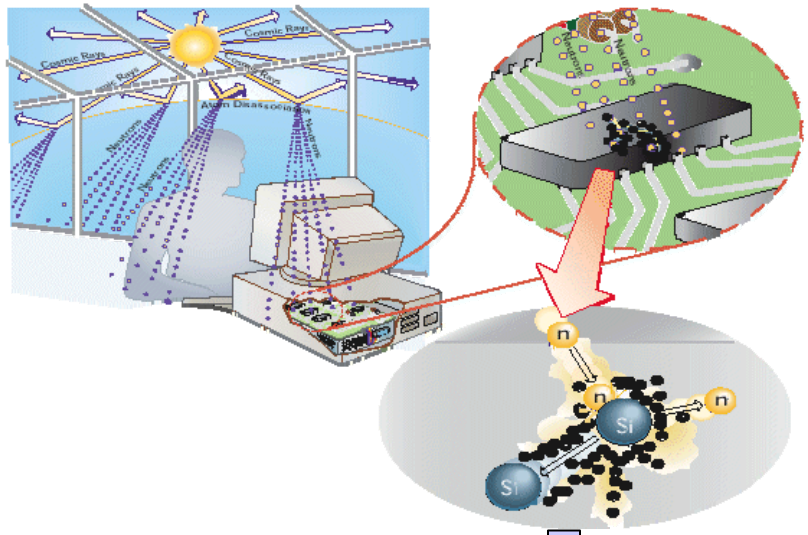
WEAR OUT MECHANISMS : WIRE BOND



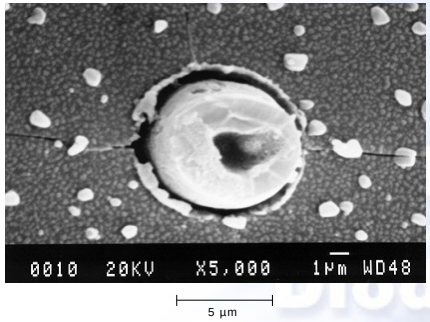




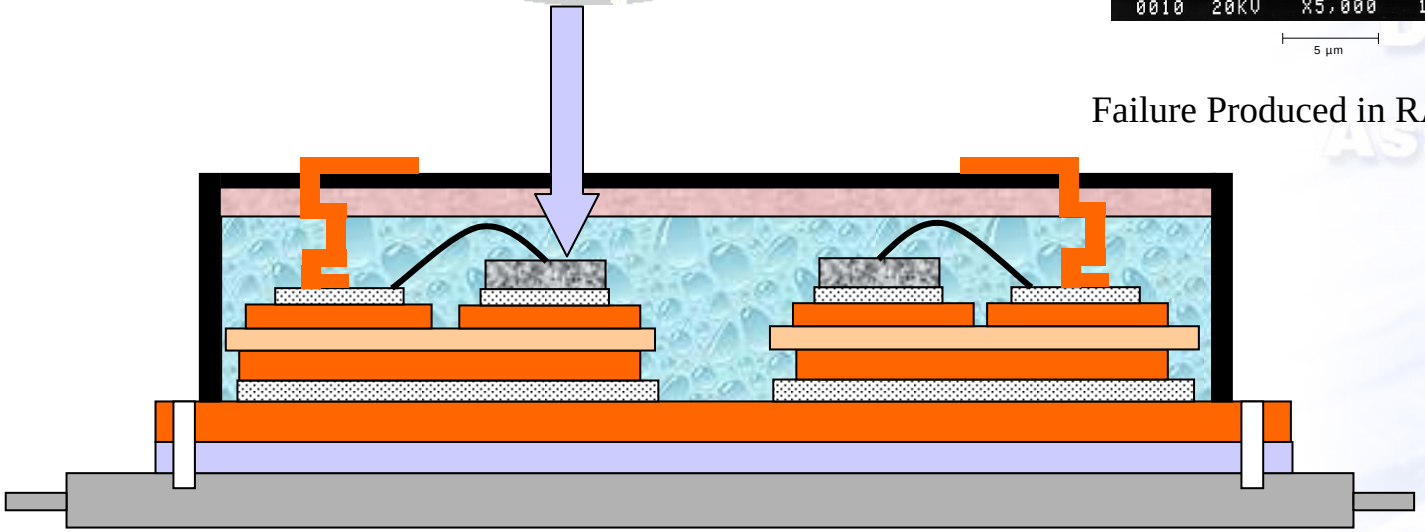
SINGLE EVENT FAILURES - COSMIC RAYS



Galactic & Solar Cosmic Rays react with Nuclei in the atmosphere to produce Neutrons
Although most of the Primary Cosmic rays and the charged particles of the cosmic ray shower are absorbed in the atmosphere, the Neutrons have long mean free paths and hence penetrate down to low altitudes



Failure Produced in RAPSDRA programme



SINGLE EVENT FAILURES - COSMIC RAYS

- The Neutron flux depends on:
  - Altitude
    - peaks at 4n/cm^2/s cf sea level 0.01n/cm^2/s
  - latitude (geomagnetic shielding)
    - worst at poles (1 order more than equator)
  - sunspot cycle
    - currently at a minima > maxima cosmic rays
- Semiconductor (IGBT) Parameters influencing failure
  - Reduced electric fields improves reliability
    - 1-D Resistivity of diode
    - 2-D Junction Curvature
    - 3-D Cell structure
- Operating Condition
  - Reducing ratio of Operating Voltage/blocking capability improves reliability

FUTURE DEVELOPMENT FOR MODULES

- PHYSICS OF FAILURE STUDIES
  - Minimise need for formal qualification
  - Improved TTM as reliability is designed in
- CONTINUED ACTIVITY IN EU AND TSB PROGRAMMES
  - Advanced manufacturing
  - Assessment and inclusion of WBG material
- INCREASED POWER DENSITY
  - Improved chip parameters
  - Novel packaging methods
  - Integrated solutions

THANK YOU FOR YOUR ATTENTION