



Spatial and Special FIB application: The debris issue

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Energy, Effects & Average Rates of Impact

stony meteor of given diameter, impact speed = 20 km/s

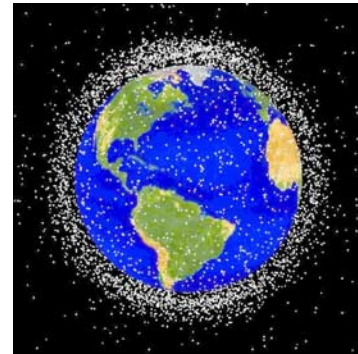
Diameter (km)	Event	Energy (TNT)	Quake (M)	Crater (km)	Est. Avg. Rate: 1 per
0.001	fire ball				6 days
0.003	fire ball				2.8 months
0.01	air burst	59.5 kilotons			4.1 years
0.03	air burst	1.61 megatons			58 years
0.1	impact	59.5 megatons	6.8	1.3 x 0.2	1,000 years
0.3	impact	1,610 megatons	7.7	3.8 x 0.4	14,000 years
1	impact	59,500 megatons	8.8	12.5 x 0.6	260,000 yrs
3	impact	1.61 million megatons	9.8	37.1 x 0.9	3.6 million yrs
10	impact	59.5 million megatons	10.8	122 x 1.2	66 million yrs
30	impact	1.61 billion megatons	11.8	327 x 1.7	920 million yrs
100	impact	59.5 billion megatons	12.8	847 x 2.2	few billion yrs



It might happen to you

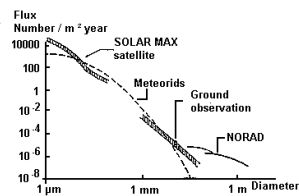


- LEO
- GEO (ring)



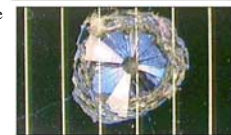
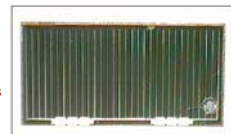
The debris problem

- Near-earth space environment is cluttered with man-made debris and naturally occurring meteoroids
- Hypervelocity impacts between any spacecraft and this particulate environment can lead to catastrophic failure

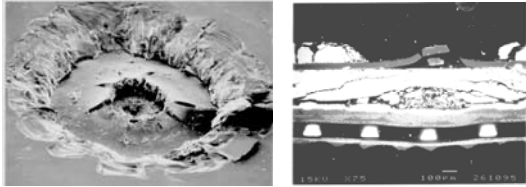


How debris expertise help us

- Small debris (<100µm) study
 - High flux = high impact event occurrence (it is possible to catch them in few time on small surfaces)
 - Impact analyses: origin of the debris (man made or natural), size, velocity
 - LDEF (Long Duration Exposure Facility)
 - MOS (debris sensor)
- Material choice to avoid debris or fragmentation
- Shielding, orbits ...



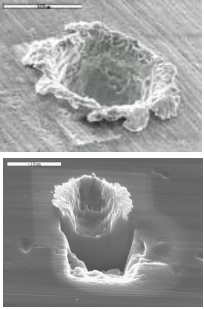
CNES Cross section ("big" impact)



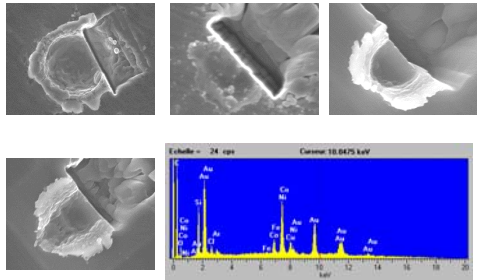
- Impact on solar cell: ejected mass >> incident particle mass

CNES Fib use (retrieved samples)

- Several impact analyses possible on the same sample
 - Only few sample coming from space (LDEF, MIR, Shuttle, ...)
 - Very useful for cloud of debris or for statistical issues)
- Cross sectioning to improve microanalysis
 - Debris residues at the hole bottom
 - thin plate for improved X microanalysis
 - thin plate for TEM

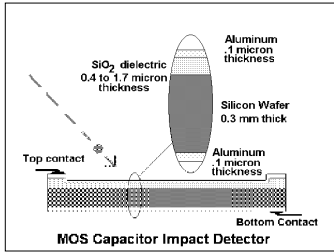


CNES Fib use (other retrieved samples)



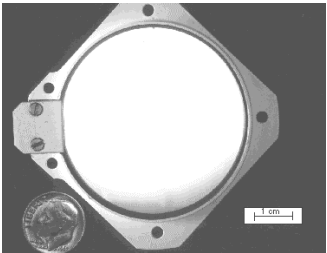
CNES MOS sensor (electric detection)

- evolution of the debris population
- Dating of the events during the mission
- Validation of the simulation models
- Influence geometry of the structures.
- Study of new orbits



CNES MOS sensor (2)

- Capacitor discharged by Impact
- Capacitor recharged after Impact
- Design issues:
 - Avoid permanent short-circuits
 - Avoid new debris after impact
- We use FIB again to design and calibrate the sensor



CNES MOS sensor ground calibration

- sensor debug
 - Calibration test
 - Max Planck Institute
 - 2 MeV Van Der Graaf
 - Iron particle
 - 0.3 μm, 3 μm
 - 1 to 15 km/s
- Challenges
 - Discharge f(Ec)
 - Threshold f(Ec, dielectric thickness, bias voltage)

