JET PROPULSION LABORATORY
M.Sandor 7/12/96
Project: MGS DRAM Module assembled by Teledyne
Vendor: Mitsubishi Device: M5M44100A (commercial die) Process:

ELECTROMIGRATION AND
CURRENT DENSITY CALCULATION FOR
SINGLE OR MULTIPLE VIA FROM METAL 2 TO METAL1

Technology:CMOS DLM 4-Layer Poly (.6um)
Passivation: Nitride/Oxide

t50 and t01 TIME TO FAILURE (for log-normal distribution)
where t50= B50*(A*J^-n)*exp(Ea/KT) [BLACK'S EQUATION]

Enter variables in red.	Enter	Unit	Calculation			Enter	Unit		Calculation	Unit
Metal 1 width	0.80	um						B01(constant)=	3.94E+14	(A/cm2)^2/cm2*h
			Area(metal)=	3.6E-09	B50(constant)(Partridge)=	1.42E+15	(A/cm2)^2/cm2*h	where B01=B50*e(sigma*Z)		
Metal 1 thickness	0.45	um	A1 in cm2=	3.1416E-09	n(current density exponent)=	2		sigma of failure distribution=ln(t.50/t.16)/1=0.55		
			CD@A1=	7.96E+04				Z=from statistics table		
Contact via opening size (oxide)	1.20	um			k(Boltzmann constant)=	8.62E-05	ev/K			
Contact via size at A1(metal 1)	1.10	um	A1 in um2=	0.31416						
Metal 1 thickness at step	0.10	um			T(temperature)=	343	K			
Via metal 1 voiding	0.00									
Step coverage at via (edge ratio)			22.2%		Ea(activation energy for EM)=	0.558	ev			
Step coverage at via (conical area ratio)			87.27%		[for Al-Si]					
Typical current in metal 1 interconnect(25	0.25	ma						Temp. AF =	2.37	
If adjusted for high temperature(.3%/C)=	0.22	ma	Temperature rise in A1 due					relative to 55C		
Temperature(max operationg +Junct rise)	70	Cent	to i2r heating=	0.02					Flight units	ChiX	Rejects
Nominal capacitance	5.00	pf	Temperature rise in metal					case1	50	2.3	0.000
VDD	5.50	Volts	interconnect =	0.01				case2	50	2.3	0.000
Switching period of device	1000.00	ns						case3	50	2.3	0.000
Operating frequency of device	1.00	Mhz									

JPL flight equipment reliability
requirements for mission Class A & B
R= 0.01%/1000hr at 85C maximum
S= 0.001%/1000hr at 85C maximum

															Failure Rate @90%CL using Poisson Statistic		Failure Rate @ 90%CL	
Case 1:Current density in single via =			7.96E+04	A/cm2					t50dc=	110263	hrs	13	yrs					
[This is worst case]			0.80	ma/um2					t.01dc=	30611	hrs	3.5	yrs		6.3379E-02	%/1000 hrs.	633.7949	FITS
Case 2: C.D. with multiple via =	6	cts.	1.33E+04	A/cm2					t50dc=	3969452	hrs	453	yrs					
[This is typical case]									t.01dc=	1102001	hrs	125.8	yrs		1.7605E-03	%/1000 hrs.	17.60541	FITS
Case 3: C.D. w/o via (metal interconnect) =			6.94E+04	A/cm2					t50dc=	165914	hrs	19	yrs					
[This is best case]									t.01dc=	46061	hrs	5.3	yrs		4.2121E-02	%/1000 hrs.	421.2054	FITS
Case 1: Current density in single via @ 1 Mhz			1.05E+04	A/cm2					Case 1 with 50% duty cycle									
(alternate calculation method: Jmax=(1.2xCxVdd)/(periodxA1)									t50ac=	441050	hrs	50	yrs					
									t.01ac=	122445	hrs	14.0	yrs		1.5845E-02	%/1000 hrs.	158.4487	FITS

Burn-in time + Mission time in hrs= 20000 Miss Temp= 70 Survival of Probability for 2.29 YRS

CASE 1 (Accept = >0.99999)
Ps= 0.99999012 **PASS**
z= -4.268
sigma= 0.40

CASE 2
Ps= 1.00000000 **PASS**
z= -13.227

CASE 3
Ps= 0.99999993 **PASS**
z= -5.289

CASE 1 @ 1 Mhz
Ps= 1.00000000 **PASS**
z= -14.733

LITERATURE SEARCH REFERENCE

AL/Si Source	Ea	B(50)	sigma
FA	0.302	1.15x10E18	0.47
FA	0.325	6.81x10E17	0.72
Buehler	0.41	7.17x10E16	0.29
Buehler	0.46	3.41x10E16	.39/.47
Black 69	0.48	4.93x10E15	-
Black 78	0.544	2.11x10E15	-
Black 82	0.558	1.41x10E15	0.40
Black 69	0.84	2.00x10E12	-
Black 69	1.20	1.17x10E9	-
Si in AL (>210C)			
Black 78	0.889	4.39x10E12	-
Cu doped AL/Si			
2%	0.670	6.817x10E14	-
4%	0.703	6.070x10E14	0.4