Government Systems Group

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DATE: August 24, 1995

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TO: G. Kramer/311
FROM: K. Sahu/300.1 K Sahu
SUBJECT: Radiation Report on 1020B
Control No. 11951

cc: R. Katz/738.2
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A radiation evaluation was performed on 1020B (Field Programmable Gate Array) to determine the total dose tolerance of these parts. A brief summary of the test results is provided below. For detailed information, refer to Tables I through IV and Figures 1, 2 and 3.

The total dose testing was performed using a Co^{60} gamma ray source. During the radiation testing, six parts were irradiated under bias (see Figure 1 for bias configuration), and two parts were used as control samples. Three of the irradiated parts (S/N 405, 406 and 407) were burned-in (BI) by the manufacturer before irradiation at 125°C for 160 hours and the other three (S/N 461, 464 and 465) were not burned-in (NBI). This was done in order to determine the effect of burn-in on radiation sensitivity. The wafer number was 5.

The total dose radiation levels were 5, 10, 15, 20, 30 and 50 krads*. The dose rate was 0.10 krads/hour (see Table II for radiation schedule). After each radiation exposure, parts were electrically tested according to the test conditions and the specification limits** listed in Table III. These tests included six functional tests, three at 1 Mhz, with Vcc = 4.5 V, 5.0 V and 5.5 V, and three at 5 Mhz, with Vcc = 4.5 V, 5.0 V and 5.5 V.

All parts passed initial electrical measurements. All irradiated parts passed all electrical and functional tests up to and including the 5 krad irradiation level.

After the 10 krad irradiation, S/N 464 (NBI) marginally exceeded the maximum specification limit of 20 mA for ICCH3, with a reading of 23.09 mA. All other irradiated parts passed all other electrical and functional tests at this level.

After the 15 krad irradiation, all irradiated parts exceeded the maximum specification limit for ICCH3, with readings ranging from 22.7 to 38.8 mA, and exceeded the maximum specification limit of 20 mA for ICCH1, with readings ranging from 20.9 to 256 mA (the maximum the test equipment was set up to measure). In addition, all irradiated parts except S/N 405 (BI) exceeded the maximum specification limit of 20 mA for both ICCH2 and ICCL3, with readings ranging from 22.7 to 33.8 mA, and from 22.4 to 32.8 mA, respectively. S/N 406 (BI), and 464 and 465 (NBI) exceeded the maximum specification limit of 20 mA for ICCL2, with readings ranging from 20.2 to 28.1 mA, and S/N 407 (BI) and 461, 464 and 465 (NBI) exceeded the maximum specification limit for ICCL1, with readings ranging from 21.8 to 219.9 mA. All irradiated parts passed all other electrical and functional tests at this level.

*The term rads, as used in this document, means rads(silicon). All radiation levels cited are cumulative.
**These are manufacturer's pre-irradiation data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

After the 15 krad electrical tests, the parts were annealed at 25°C for 192 hours, after which the parts were retested. At this point, all irradiated parts exceeded the maximum specification limit for ICCH1 and ICCH3, with readings ranging from 20.9 to 256 mA, S/N 407 (BI) and 461 (NBI) exceeded the maximum specification limit for ICCL1, ICCH2 and ICCL3, with readings of 22.7 and 24.2, and 22.4 and 23.8 mA, respectively. S/N 406 (BI), and 464 and 465 (NBI) exceeded the maximum specification limit for ICCL2, with readings ranging from 20.2 to 28.1 mA. All irradiated parts passed all other electrical and functional tests at this level.

After the 20 krad irradiation, S/N 464 (NBI) exceeded the maximum specification limit for ICCH2 and ICCH3, with readings of 21.2 and 23.4 mA, respectively. All irradiated parts passed all other electrical and functional tests at this level.

After the 30 krad irradiation, S/N 405 and 406 (BI) failed Functional Test # 4, and S/N 406 failed Functional Test # 1. All irradiated parts exceeded specification limits for all ICCH and ICCL tests, with readings ranging from 22.5 to 242 mA. In addition, S/N 406 (BI) and 464 (NBI) read 0 V for several VOH1 tests, which also constitutes functional failure.

After the 30 krad irradiation, the parts were annealed at 25°C for 240 hours, after which the parts were retested. At this point, all irradiated parts passed all functional tests. All irradiated parts except S/N 405 (BI) exceeded the maximum specification limit for all ICC tests, with readings ranging from 21.4 to 39.0 mA. S/N 405 read within specification limits for ICCH1. In addition, S/N 465 (NBI) exceeded the maximum specification limit of 100 ns for TPLH and TPHL, with readings of 1000 µs, which is indicative of functional failure. All irradiated parts passed all other electrical and functional tests at this level.

After the 50 krad irradiation, S/N 406 (BI) and 464 (NBI) failed all six functional tests, S/N 407 (BI) failed Functional Tests # 1, 4 and 5, S/N 461 (NBI) failed Functional Tests # 1, 2, 4 and 5, and S/N 405 (BI) and 465 (NBI) continued to pass all six functional tests. S/N 406 and 407 (BI) and 461 and 464 (NBI) also exceeded specification limits for all VOH and VOL tests, which also constitutes functional failure. S/N 406 (BI) and 461 and 464 (NBI) fell outside both the minimum specification limit of -100 mA and the maximum specification limit of -10 mA for -IOS, with readings ranging from -1.2 to -900 mA. S/N 406 and 407 (BI), and S/N 461 and 464 (NBI) read 1000 µs for both TPLH and TPHL. All irradiated parts passed all other electrical tests at this level.

Table IV provides a summary of the mean and standard deviation values for each parameter after different irradiation exposures and annealing steps.

Readings for ICCL1 and ICCH1 are plotted vs. total dose in Figures. 2 and 3, respectively, for both burned-in (BI) and non burned-in (NBI) parts. As can be seen in both figures, there does not seem to be a consistent difference between BI and NBI parts, although, in several cases, the NBI parts proved to be more sensitive to radiation.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call me at (301) 731-8954.

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TABLE I. Part Information

Generic Part Number:	1020B*
Code 400 Part Number:	1020B
Code 400 Control Number:	11951
Charge Number:	EE44502
Manufacturer:	Actel
Lot Date Code:	unknown
Quantity Tested:	6
Serial Number of Control Samples:	408, 453
Serial Numbers of Radiation Samples:	405, 406, 407 (Burned-In by Mfr.) 461, 464, 465 (not Burned-In)
Wafer #:	5
Part Function:	Field Programmable Gate Array
Part Technology:	CMOS
Package Style:	84-pin CPGA
Test Equipment:	S-50
Test Engineer:	T. Scharer

* No radiation tolerance/hardness was guaranteed by the manufacturer for this part.

TABLE II. Radiation Schedule for 1020B

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	03/07/95
2) 5 KRAD IRRADIATION (0.10 KRADS/HOUR)	03/08/95
POST-5 KRAD ELECTRICAL MEASUREMENT	03/10/95
3) 10 KRAD IRRADIATION (0.10 KRADS/HOUR)	03/10/95
POST-10 KRAD ELECTRICAL MEASUREMENT	03/14/95
4) 15 KRAD IRRADIATION (0.10 KRADS/HOUR)	03/14/95
POST-15 KRAD ELECTRICAL MEASUREMENT	03/16/95
5) 192-HOUR ANNEALING @ 25°C	03/16/95
POST-192-HOUR ANNEAL ELECTRICAL MEASUREMENT	03/24/95
6) 20 KRAD IRRADIATION (0.10 KRADS/HOUR)	03/24/95
POST-20 KRAD ELECTRICAL MEASUREMENT	03/27/95
6) 30 KRAD IRRADIATION (0.10 KRADS/HOUR)	03/27/95
POST-30 KRAD ELECTRICAL MEASUREMENT	03/28/95
7) 240-HOUR ANNEALING @ 25°C	03/28/95
POST-240-HOUR ANNEAL ELECTRICAL MEASUREMENT	04/07/95
8) 50 KRAD IRRADIATION (1.47 KRADS/HOUR)	04/07/95
POST-50 KRAD ELECTRICAL MEASUREMENT	04/17/95

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS; SEE FIGURE 1.

Table III. Electrical Characteristics of 1020B

FUNCTIONAL TESTS PERFORMED

PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT 3 TEMPS
FUNCT 1	4.5V	0.0V	4.5V	FREQ=1.000MHZ	ALL I/O	VOL<1.00V , VOH>1.00V
FUNCT 2	5.0V	0.0V	5.0V	FREQ=1.000MHZ	ALL I/O	VOL<1.00V , VOH>1.00V
FUNCT 3	5.5V	0.0V	5.5V	FREQ=1.000MHZ	ALL I/O	VOL<1.00V , VOH>1.00V
FUNCT 4	4.5V	0.0V	4.5V	FREQ=5.000MHZ	ALL I/O	VOL<1.00V , VOH>1.00V
FUNCT 5	5.0V	0.0V	5.0V	FREQ=5.000MHZ	ALL I/O	VOL<1.00V , VOH>1.00V
FUNCT 6	5.5V	0.0V	5.5V	FREQ=5.000MHZ	ALL I/O	VOL<1.00V , VOH>1.00V

DC PARAMETRIC TESTS PERFORMED

PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT 3 TEMPS
VOH1	4.5V	0.00V	4.50V	LOAD= -4.0MA	OUTS	>+3.70V , <+4.50V
VOL1	4.5V	0.00V	4.50V	LOAD= +6.0MA	OUTS	>+0.00V , <+0.40V
VOH2	5.0V	0.00V	5.00V	LOAD= -4.0MA	OUTS	>+3.70V , <+5.00V
VOL2	5.0V	0.00V	5.00V	LOAD= +6.0MA	OUTS	>+0.00V , <+0.40V
IIH	5.5V	0.00V	5.5V	VIN = 5.5V	INS	>-10UA , <+10UA
IIL	5.5V	0.00V	5.5V	VIN = 0.0V	INS	>-10UA , <+10UA
-IOS	5.5V	0.00V	5.5V	VOUT= 0.0V	INS	>-100MA , <-10MA
ICCL1	4.5V	0.0V	4.5V	VOUT= 0.0V	VCC	>+0.0MA , <+20MA
ICCH1	4.5V	0.0V	4.5V	VOUT= 4.5V	VCC	>+0.0MA , <+20MA
ICCL2	5.0V	0.0V	5.0V	VOUT= 0.0V	VCC	>+0.0MA , <+20MA
ICCH2	5.0V	0.0V	5.0V	VOUT= 5.0V	VCC	>+0.0MA , <+20MA
ICCL3	5.5V	0.0V	5.5V	VOUT= 0.0V	VCC	>+0.0MA , <+20MA
ICCH3	5.5V	0.0V	5.5V	VOUT= 5.5V	VCC	>+0.0MA , <+20MA

AC PARAMETRIC TESTS PERFORMED

PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS AT +25C ONLY
TPLH	5.0V	0.00V	5.00V	VTEST= 2.0V	OUTS	>+0.0NS , <+100NS
TPHL	5.0V	0.00V	5.00V	VTEST= 2.0V	OUTS	>+0.0NS , <+100NS

Table IV: Total Dose Exposures and Annealing for 1020B /1

			Spec. Lim. /2		Initials		Total Dose Exposure (TDE) (krads)						Annealing		TDE (krads)				Annealing		TDE (krads)	
					25°C		5		10		15		192hrs.@25°C		20		30		240hrs.@25°C		50	
#	Parameters	Units	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	FUNC1, VCC=4.5V, VIL=0.0V, VIH=4.5V, 1MHz				P		P		P		P		P		P		5P1F		P		2P4F	
2	FUNC2, VCC=5.0V, VIL=0.0V, VIH=5.0V, 1MHz				P		P		P		P		P		P		P		P		3P3F	
3	FUNC3, VCC=5.5V, VIL=0.0V, VIH=5.5V, 1MHz				P		P		P		P		P		P		P		P		4P2F	
4	FUNC4, VCC=4.5V, VIL=0.0V, VIH=4.5V, 5MHz				P		P		P		P		P		P		4P2F		P		2P4F	
5	FUNC5, VCC=5.0V, VIL=0.0V, VIH=5.0V, 5MHz				P		P		P		P		P		P		P		P		2P4F	
6	FUNC6, VCC=5.5V, VIL=0.0V, VIH=5.5V, 5MHz				P		P		P		P		P		P		P		P		2P4F	
7	VOH1	V	3.7	4.5	4.22	.01	4.22	.01	4.22	.01	2.10	2.1	4.21	8.4	3.68	1.4	4.20	1.0	4.21	12	0.84	1.7
8	VOL1	mV	0	400	108	2.9	108	2.8	108	2.8	553	446	107	2.9	109	2.9	108	2.9	107	3.0	821	357
9	VOH2	V	3.7	5.0	4.73	.01	4.73	.01	4.73	.01	4.73	.01	4.73	.01	4.73	8.0	4.72	.01	4.72	.01	0.98	1.9
10	VOL2	mV	0	400	104	2.3	104	2.5	103	2.6	102	2.8	102	2.8	104	2.9	104	2.9	103	2.9	547	404
11	IIH	uA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.13	.11
12	IIL	uA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.16	.18
13	-IOS	mA	-100	-10	-36.7	.89	-36.1	.91	-36.0	.92	-35.9	.93	-35.6	.94	-35.2	.94	-35.0	.97	-35.1	1.0	-15.0	16
14	ICCL1	mA	0	20	0.53	.07	1.29	.20	9.73	2.4	121	103	15.9	3.1	30.8	7.3	30.8	8.0	23.9	3.5	168	71
15	ICCH1	mA	0	20	1.83	.14	2.68	.37	12.1	2.9	157	105	19.6	3.7	16.4	133	16.4	145	28.8	4.6	194	82
16	ICCL2	mA	0	20	0.69	.07	1.73	.25	12.0	2.8	21.5	4.3	19.2	3.7	32.1	4.3	32.1	4.7	27.5	3.8	211	91
17	ICCH2	mA	0	20	1.87	.12	3.05	.34	14.4	3.3	26.1	5.2	23.0	4.3	37.7	5.6	37.7	6.1	32.5	5.0	212	89
18	ICCL3	mA	0	20	0.95	.07	2.17	.32	14.5	3.3	25.5	4.9	22.5	4.1	36.1	4.7	36.1	5.1	30.9	4.3	165	111
19	ICCH3	mA	0	20	1.96	.11	3.47	.43	17.1	3.7	30.1	5.7	26.6	4.9	42.0	6.0	42.0	6.6	36.2	5.4	167	109
20	TPLH	ns	0	100	38.4	5.5	38.4	6.0	38.5	7.1	40.1	10	38.4	14	40.4	14	40.2	14	37.9	14	2P4F	
21	TPHL	ns	0	100	40.9	4.3	40.9	6.7	41.0	9.0	41.1	11	42.4	12	45.0	9.9	40.4	16	5P1F		2P4F	

Notes:

1/ The mean and standard deviation values were calculated over the six parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.

2/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

3/ In the functional Tests, "P" means that all parts passed this test at this irradiation or annealing level, "F" means that all parts failed this test at this irradiation or annealing level and "nPmF" means that n parts passed at this level and m parts failed at this level.

Radiation-sensitive parameters: ICCL, ICCH, TPLH, TPHL, VOH, VOL, IOS, FUNC.

Wafer #: 5

S/N#s:

BI: 405, 406, 407

NBI: 461, 464, 465

Control: 408, 453

Figure 1. Radiation Bias Circuit for A1020B

Signal	LocationBurn-In Board	
PRA_	A11	GND
PRB_	B10	GND
MODE	E11	GND
SDI	B11	VCC
DCLK	C10	VCC
CLK	F9	GND
INX1	L6	VCC
INX2	G11	VCC
IN1A	J11	GND
IN2A	H10	GND
IN_AND3	L4	VCC
IN_AND4	K9	GND
IN_OR3	F11	VCC
IN_OR4	D11	GND
IN_NAND4	L5	VCC
IN_NOR4	G3	GND
DA	H2	VCC
RESET_	K3	GND
ENCNTR	C6	VCC
CNTRLD_	B4	GND
RESETCENTR_	A7	GND
CLOCK	F9	GND
OUTX1	A10	VCC/2
OUTX2	K11	VCC/2
OUTA	K10	VCC/2
O_AND3	J5	VCC/2
O_AND4	G9	VCC/2
O_OR3	L11	VCC/2
O_OR4	D10	VCC/2
O_NAND4	K6	VCC/2
O_NOR4	G1	VCC/2
QA0	L1	VCC/2
QA1	K1	VCC/2
QA2	L2	VCC/2
YO11	A3	VCC/2
YO10	A4	VCC/2
YO9	B3	VCC/2
YO8	A2	VCC/2
Y07	C7	VCC/2
Y06	A6	VCC/2
YO5	A5	VCC/2
YO4	C5	VCC/2
YO3	B6	VCC/2
YO2	A9	VCC/2
YO1	A8	VCC/2
YO0	B8	VCC/2

NOTES:

1. VCC = 5.0 V, +/- 0.5 V
2. VCC/2 = 2.5 V +/- 0.25 V
3. All outputs through 2.2 kohm +/- 10% 1/4 W resistors to VCC/2
4. Inputs connected to VCC through 2.2 kohm resistor
5. Inputs connected to GND do not require resistors

VCC: K2, B5, F1, G2, K7, E9, E10 (NO RESISTOR)
GND: B7, E2, E3, K5, F10, G10, E11

Figure 2. Comparison of Burned-In (BI) vs. Non Burned-In (NBI) Parts
1020B ICCL Wafer 5

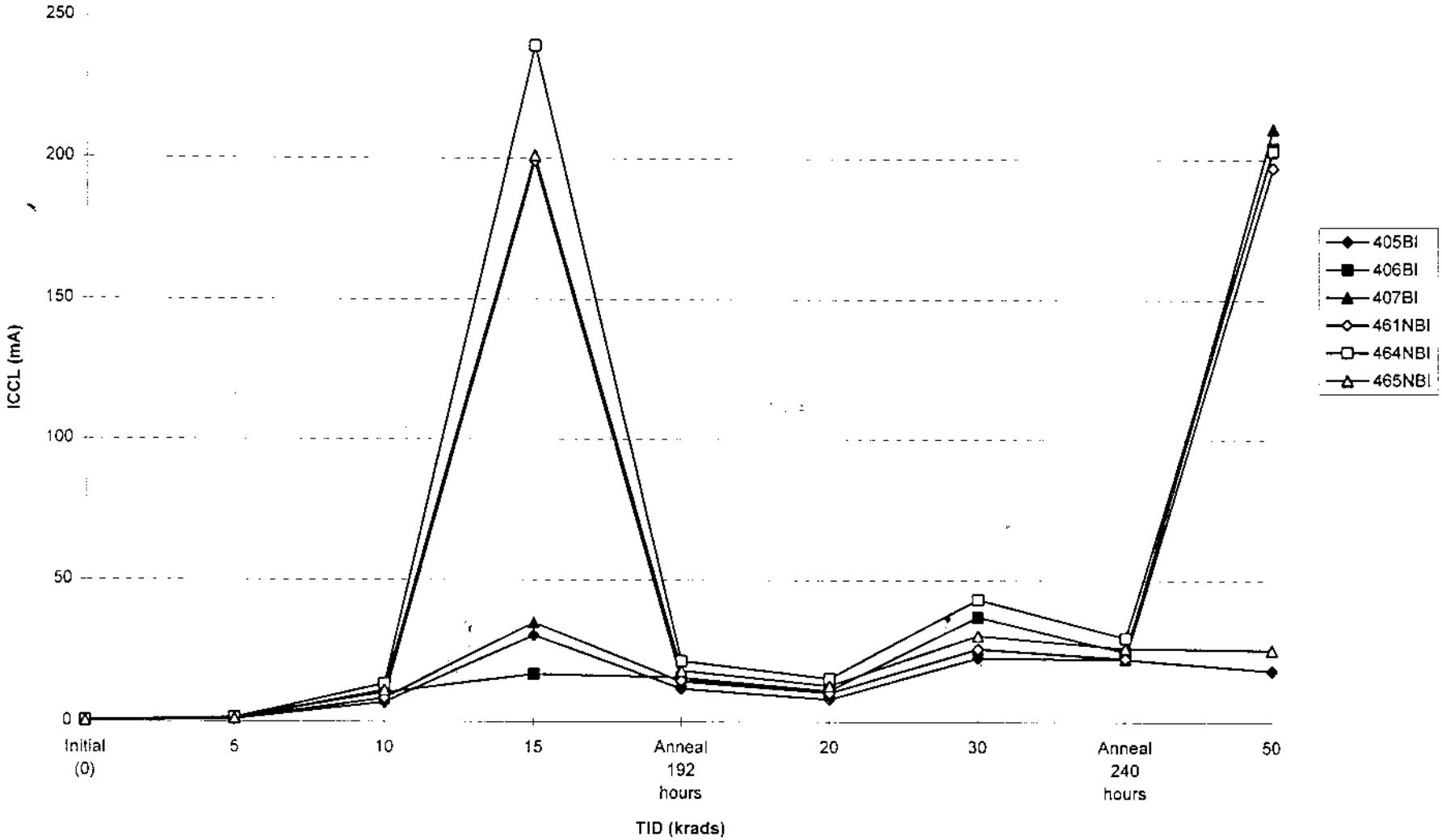

Figure 3. Comparison of Burned-In (BI) vs. Non Burned-In (NBI) Parts
1020B ICCH Wafer 5