1/3.2-Inch 3.1-Megapixel CMOS Active-Pixel Digital Image Sensor Die

MT9T012

For the product data sheet, refer to Micron's Web site: www.micron.com

Features

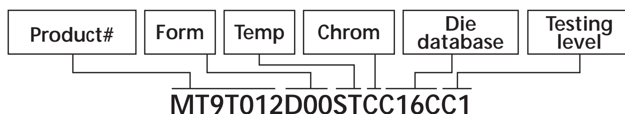
- Micron® DigitalClarity® image sensor technology
- Superior low-light performance
- Low dark current
- Simple two-wire serial interface
- Auto black level calibration
- Support for external mechanical shutter
- Support for external LED or xenon flash
- High frame-rate preview mode with arbitrary down-size scaling from maximum resolution
- Programmable controls: gain, frame size/rate, exposure, left-right and top-bottom image reversal, window size, and panning
- SMIA-compatible
- Data interfaces: parallel and sub-low-voltage differential signaling (sub-LVDS)
- On-die PLL
- Bayer-pattern down-size scaler

General Physical Specifications

- Die thickness: 200µm ±12µm
  (Consult factory for other die thickness)
- Backside wafer surface of bare silicon
- Typical metal 1 thickness: 3.1kÅ
- Typical metal 2 thickness: 3.1kÅ
- Typical metal 3 thickness: 6.1kÅ
- Metallization composition: 99.5 percent Al and 0.5 percent Cu over Ti
- Typical topside passivation:
  2.2kÅ nitride over 6.0kÅ of undoped oxide
- Passivation openings (MIN): 75µm x 90µm

Order Information

MT9T012D00STCC16CC1



Notes: 1. Consult die distributor or factory before ordering to verify long-term availability of these die products.

Die Database C16C

- Die outline, see Figure 3 on page 10
- Die size (stepping interval):
  6,554.30µm x 6,662.30µm
- Singulated die size: 6,512 ±25µm x 6,620 ±25µm
- Bond Pad Location and Identification Tables, see pages 6–9

Option

- Form
  – Die D
- Testing
  – Standard (level 1) probe C1

Key Performance Parameters

- Optical format: 1/3.2-inch QXGA (4:3)
- Active imager size: 4.52mm(H) x 3.40mm(V), 5.66mm diagonal
- Active pixels: 2056H x 1544V
- Pixel size: 2.2µm x 2.2µm
- Color filter array: RGB Bayer pattern
- Chief ray angle: 21.36° at 85 percent image height
- Shutter type: electronic rolling shutter (ERS)
- Maximum data rate/master clock:
  64 Mp/s with a 64 MHz internal clock
- Frame rate:
  QXGA (2048H x 1536V), programmable up to 15 fps
  VGA (640H x 480V), programmable up to 30 fps
- ADC resolution: 10-bit, on-die (61dB)
- Responsivity: 0.53 V/lux-sec (550nm)
- Dynamic range: 59.5dB
- SNR MAX: 37.7dB
- Supply voltage:
  Analog 2.40–3.10V (2.50V or 2.80V nominal)
  Digital 1.70–1.90V (1.80V nominal)
  I/O digital 1.70–3.10V
- Power consumption: 205mW
- Operating temperature: –30°C to +70°C

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General Description

The Micron Imaging MT9T012 die is a QXGA-format 1/3.2-inch CMOS active-pixel digital image sensor, with a pixel array of 2056H x 1544V (2048H x 1536V with a 4-pixel border on each edge). It incorporates sophisticated on-die camera functions, such as windowing, mirrowing, column and row skip modes, and snapshot mode. It is programmable through a simple two-wire serial interface and has very low power consumption.

The MT9T012 digital image sensor die features DigitalClarity—Micron's breakthrough, low-noise CMOS imaging technology that achieves CCD image quality (based on signal-to-noise ratio and low-light sensitivity) while maintaining the inherent size, cost, and integration advantages of CMOS.

When operated in its default mode, the sensor generates a QXGA image at 15 frames per second (fps). An on-die analog-to-digital converter (ADC) generates a 10-bit value for each pixel. The pixel data either is encoded with line and framing information in a high-speed CCP2 differential data stream or is output on a 10-bit output bus and qualified by an output data clock (PIXCLK), together with LINE_VALID and FRAME_VALID signals. A flash output strobe is provided to allow an external xenon or LED light source to synchronize with the sensor exposure time. Additional I/O signals support the provision of an external mechanical shutter. The sensor can be programmed by the user to control the frame size, exposure, gain setting, and other parameters.

Die Testing Procedures

Micron imager die products are tested with a standard probe (C1) test level. Wafer probe is performed at an elevated temperature to ensure product functionality in Micron's standard package. Because the package environment is not within Micron's control, the user must determine the necessary heat sink requirements to ensure that the die junction temperature remains within specified limits.

Image quality is verified through various imaging tests. The probe functional test flow provides test coverage for the on-die ADC, logic, serial interface bus, and pixel array. Test conditions, margins, limits, and test sequence are determined by individual product yields and reliability data.

Micron retains a wafer map of each wafer as part of the probe records, along with a lot summary of wafer yields for each lot probed. Micron reserves the right to change the probe program at any time to improve the reliability, packaged device yield, or performance of the product.

Die users may experience differences in performance relative to Micron's data sheets. This is due to differences in package capacitance, inductance, resistance, and trace length.

Functional Specifications

The specifications provided in this document are for reference only. For functional and parametric specifications, refer to the product data sheet found on Micron's Web site.

Bonding Instructions

The C16C imager die has 60 bond pads. Refer to Table 1 and Table 2, on pages 6–9, for a complete list of bond pads and coordinates.

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The die also has several pads defined as “do not use.” These pads are reserved for engineering purposes and should not be used. Bonding these pads could result in a nonfunctional die.

Figure 1 on page 4 shows the MT9T012 typical die connections. For low-noise operation, the MT9T012 die requires separate supplies for analog and digital power. Power supply rails should be decoupled to ground using capacitors. Use of inductance filters is not recommended.

Storage Requirements

Micron die products are packaged for shipping in a cleanroom environment. Upon receipt, the customer should transfer the die to a similar environment for storage. Micron recommends the die be maintained in a filtered nitrogen atmosphere until removed for assembly. The moisture content of the storage facility should be maintained at 30 percent relative humidity ±10 percent. ESD damage precautions are necessary during handling. The die must be in an ESD-protected environment at all times for inspection and assembly.

Product Reliability Monitors

Reliability of all packaged products is monitored by ongoing reliability evaluations. Micron’s QRA department continually samples product families for reliability studies. These samples are subjected to a battery of tests known as the “Accelerated Life” and “Environmental Stress” tests. During these tests, devices are stressed for many hours under conditions designed to simulate years of normal field use. A summary of these product family evaluations is published on a regular basis.

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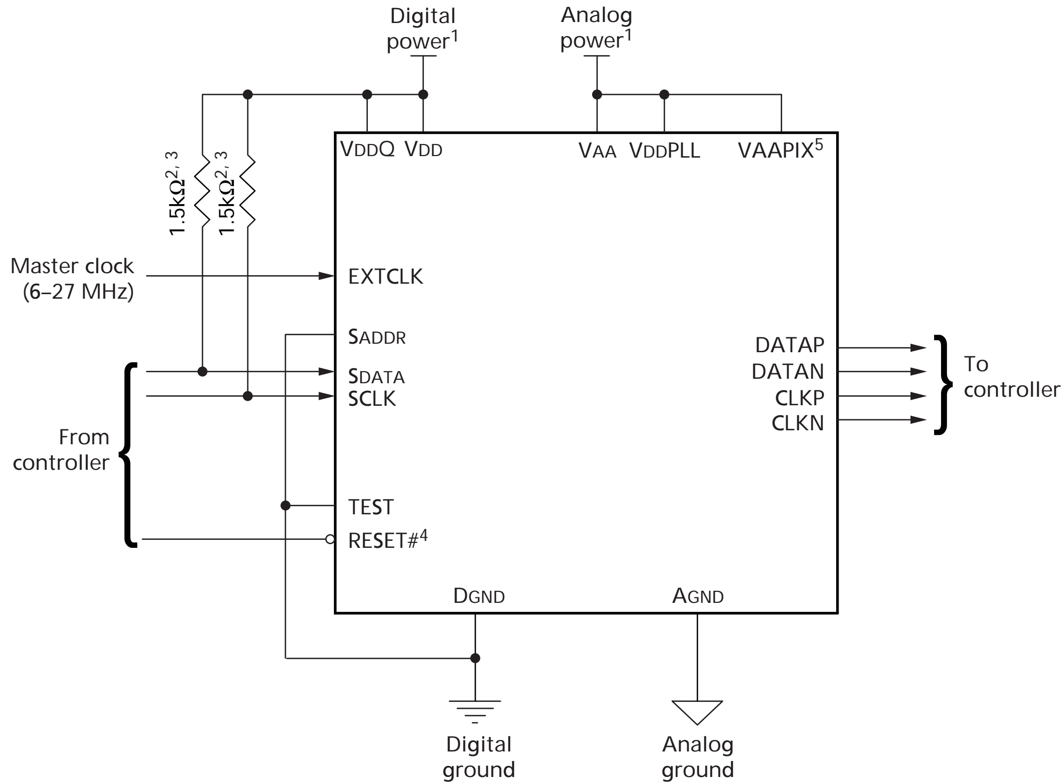
Output Modes

By default, the MT9T012 powers up as an SMIA-compatible sensor with the serial pixel data interface enabled. A typical configuration in this mode is shown in Figure 1. The MT9T012 can also be configured to operate with a parallel pixel data interface. A typical configuration in this mode is shown in Figure 2 on page 5. These two operating modes are described in “Control of the Signal Interface” in the product data sheet.

Figure 1: Typical Configuration (Connection) – Serial Output Mode



Notes:
1. All power supplies should be adequately decoupled.
2. A resistor value of 1.5kΩ is recommended, but may be greater for slower two-wire speed.
3. This pull-up resistor is not required if the controller drives a valid logic level on SCLK at all times.
4. Also referred to as XSHUTDOWN.
5. VAA and VAAPIX must be tied together.

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Figure 2: Typical Configuration (Connection) – Parallel Output Mode

Digital power[1]
Analog power[1]
VDDQ VDD VAA VDDPLL VAAPIX[5]
1.5kΩ[2, 3]
1.5kΩ[2, 3]
Master clock (6–27 MHz)
EXTCLK
DOUT[9:0]
SADDR
SDATA
SCLK
GPI1
GPI0
GPI2
GPI3
TEST
RESET#
PIXCLK
LINE_VALID
FRAME_VALID
FLASH
SHUTTER
To controller
From controller or pulled HIGH/LOW as module ID[4]
DGND
AGND
Digital ground
Analog ground

Notes:
1. All power supplies should be adequately decoupled.
2. A resistor value of 1.5kΩ is recommended, but may be greater for slower two-wire speed.
3. This pull-up resistor is not required if the controller drives a valid logic level on SCLK at all times.
4. The GPI pins either can be statically pulled HIGH/LOW to be used as module IDs or can be programmed to perform special functions (TRIGGER, OE#, STANDBY) to be dynamically controlled.
5. VAA and VAAPIX must be tied together.

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Bond Pad Location and Identification Tables

Table 1: MT9T012 Bond Pad Location and Identification from Center of Pad 1

Pad	MT9T012	"X"[1] Microns	"Y"[1] Microns	"X"[1] Inches	"Y"[1] Inches
1	CLKN	0.00	0.00	0.0000000	0.0000000
2	CLKP	290.00	0.00	0.0114173	0.0000000
3	DATAN	656.64	0.00	0.0258520	0.0000000
4	DATAP	946.64	0.00	0.0372693	0.0000000
5	DGND4	2053.36	0.00	0.0808409	0.0000000
6	VDDQ4	2195.20	0.00	0.0864252	0.0000000
7	AGND1	2968.48	0.00	0.1168693	0.0000000
8	DNU[2]	3099.52	0.00	0.1220283	0.0000000
9	VAA1	3230.56	0.00	0.1271874	0.0000000
10	DNU	3372.40	0.00	0.1327717	0.0000000
11	AGND2	3503.44	0.00	0.1379307	0.0000000
12	DNU	3634.48	0.00	0.1430898	0.0000000
13	VAA2	3765.52	0.00	0.1482488	0.0000000
14	VAAPIX3	5374.72	–6314.21	0.2116031	–0.2485909
15	VAAPIX2	5243.68	–6314.21	0.2064441	–0.2485909
16	VAAPIX1	5112.64	–6314.21	0.2012850	–0.2485909
17	VAA3	4109.68	–6314.21	0.1617984	–0.2485909
18	DNU	3978.64	–6314.21	0.1566394	–0.2485909
19	AGND3	3847.60	–6314.21	0.1514803	–0.2485909
20	DNU	3716.56	–6314.21	0.1463213	–0.2485909
21	VAA4	3574.72	–6314.21	0.1407370	–0.2485909
22	DNU	3443.68	–6314.21	0.1355780	–0.2485909
23	AGND4	3312.64	–6314.21	0.1304189	–0.2485909
24	VDD4	2295.28	–6314.21	0.0903654	–0.2485909
25	RESET#[3]	1876.30	–6314.21	0.0738699	–0.2485909
26	GPI3	1700.51	–6314.21	0.0669490	–0.2485909
27	GPI2	1536.46	–6314.21	0.0604904	–0.2485909
28	DGND5	1383.04	–6314.21	0.0544504	–0.2485909
29	SCLK	1229.63	–6314.21	0.0484104	–0.2485909
30	GPI1	1065.58	–6314.21	0.0419518	–0.2485909
31	SDATA	850.40	–6314.21	0.0334803	–0.2485909
32	GPI0	662.38	–6314.21	0.0260778	–0.2485909
33	SHUTTER	–689.75	–6110.71	–0.0271553	–0.2405789
34	SADDR	–689.75	–5922.68	–0.0271553	–0.2331764
35	TEST[4]	–689.75	–5746.89	–0.0271553	–0.2262555
36	DGND1	–689.75	–5599.35	–0.0271553	–0.2204467
37	DOUT0	–689.75	–5406.55	–0.0271553	–0.2128561
38	VDD1	–689.75	–5224.23	–0.0271553	–0.2056781
39	VDDQ1	–689.75	–5082.39	–0.0271553	–0.2000939
40	DOUT1	–689.75	–4889.59	–0.0271553	–0.1925033
41	DOUT2	–689.75	–4677.59	–0.0271553	–0.1841569
42	DOUT3	–689.75	–4423.03	–0.0271553	–0.1741348

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Table 1: MT9T012 Bond Pad Location and Identification from Center of Pad 1 (continued)

Pad	MT9T012	"X"[1] Microns	"Y"[1] Microns	"X"[1] Inches	"Y"[1] Inches
43	DOUT4	–689.75	–4211.03	–0.0271553	–0.1657884
44	DGND3	–689.75	–4018.23	–0.0271553	–0.1581978
45	DOUT5	–689.75	–3825.43	–0.0271553	–0.1506073
46	VDD3	–689.75	–3643.11	–0.0271553	–0.1434293
47	VDDQ3	–689.75	–3501.27	–0.0271553	–0.1378451
48	DOUT6	–689.75	–3329.75	–0.0271553	–0.1310923
49	DOUT7	–689.75	–3075.19	–0.0271553	–0.1210703
50	DOUT8	–689.75	–2863.19	–0.0271553	–0.1127238
51	DOUT9	–689.75	–2608.63	–0.0271553	–0.1027018
52	PIXCLK	–689.75	–2396.63	–0.0271553	–0.0943553
53	DGND2	–689.75	–2203.83	–0.0271553	–0.0867648
54	FRAME_VALID	–689.75	–2011.03	–0.0271553	–0.0791742
55	VDD2	–689.75	–1828.71	–0.0271553	–0.0719963
56	VDDQ2	–689.75	–1686.87	–0.0271553	–0.0664120
57	LINE_VALID	–689.75	–1515.35	–0.0271553	–0.0596593
58	FLASH	–689.75	–1260.79	–0.0271553	–0.0496372
59	EXTCLK	–689.75	–1048.79	–0.0271553	–0.0412907
60	VDDPLL	–689.75	–624.87	–0.0271553	–0.0246010

Notes:
1. Reference to center of each bond pad from center of bond pad number 1.
2. DNU = do not use. See "Bonding Instructions" on page 2.
3. Also referred to as XSHUTDOWN.
4. TEST pad must be tied to DGND for normal device operation.

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Table 2: MT9T012 Bond Pad Location and Identification from Center of Die (0,0)

Pad	MT9T012	"X"[1] Microns	"Y"[1] Microns	"X"[1] Inches	"Y"[1] Inches
1	CLKN	–2413.36	3157.11	–0.0950142	0.1242955
2	CLKP	–2123.36	3157.11	–0.0835969	0.1242955
3	DATAN	–1756.72	3157.11	–0.0691622	0.1242955
4	DATAP	–1466.72	3157.11	–0.0577449	0.1242955
5	DGND4	–360.00	3157.11	–0.0141732	0.1242955
6	VDDQ4	–218.16	3157.11	–0.0085890	0.1242955
7	AGND1	555.12	3157.11	0.0218551	0.1242955
8	DNU[2]	686.16	3157.11	0.0270142	0.1242955
9	VAA1	817.20	3157.11	0.0321732	0.1242955
10	DNU	959.04	3157.11	0.0377575	0.1242955
11	AGND2	1090.08	3157.11	0.0429165	0.1242955
12	DNU	1221.12	3157.11	0.0480756	0.1242955
13	VAA2	1352.16	3157.11	0.0532346	0.1242955
14	VAAPIX3	2961.36	–3157.11	0.1165890	–0.1242955
15	VAAPIX2	2830.32	–3157.11	0.1114299	–0.1242955
16	VAAPIX1	2699.28	–3157.11	0.1062709	–0.1242955
17	VAA3	1696.32	–3157.11	0.0667843	–0.1242955
18	DNU	1565.28	–3157.11	0.0616252	–0.1242955
19	AGND3	1434.24	–3157.11	0.0564661	–0.1242955
20	DNU	1303.20	–3157.11	0.0513071	–0.1242955
21	VAA4	1161.36	–3157.11	0.0457228	–0.1242955
22	DNU	1030.32	–3157.11	0.0405638	–0.1242955
23	AGND4	899.28	–3157.11	0.0354047	–0.1242955
24	VDD4	–118.08	–3157.11	–0.0046488	–0.1242955
25	RESET#[3]	–537.07	–3157.11	–0.0211443	–0.1242955
26	GPI3	–712.86	–3157.11	–0.0280652	–0.1242955
27	GPI2	–876.91	–3157.11	–0.0345238	–0.1242955
28	DGND5	–1030.32	–3157.11	–0.0405638	–0.1242955
29	SCLK	–1183.74	–3157.11	–0.0466037	–0.1242955
30	GPI1	–1347.79	–3157.11	–0.0530624	–0.1242955
31	SDATA	–1562.96	–3157.11	–0.0615339	–0.1242955
32	GPI0	–1750.99	–3157.11	–0.0689364	–0.1242955
33	SHUTTER	–3103.11	–2953.60	–0.1221695	–0.1162835
34	SADDR	–3103.11	–2765.58	–0.1221695	–0.1088809
35	TEST[4]	–3103.11	–2589.79	–0.1221695	–0.1019600
36	DGND1	–3103.11	–2442.24	–0.1221695	–0.0961512
37	DOUT0	–3103.11	–2249.44	–0.1221695	–0.0885606
38	VDD1	–3103.11	–2067.12	–0.1221695	–0.0813827
39	VDDQ1	–3103.11	–1925.28	–0.1221695	–0.0757984
40	DOUT1	–3103.11	–1732.48	–0.1221695	–0.0682079
41	DOUT2	–3103.11	–1520.48	–0.1221695	–0.0598614
42	DOUT3	–3103.11	–1265.92	–0.1221695	–0.0498394
43	DOUT4	–3103.11	–1053.92	–0.1221695	–0.0414929
44	DGND3	–3103.11	–861.12	–0.1221695	–0.0339024
45	DOUT5	–3103.11	–668.32	–0.1221695	–0.0263118

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Table 2: MT9T012 Bond Pad Location and Identification from Center of Die (0,0) (continued)

Pad	MT9T012	"X"[1] Microns	"Y"[1] Microns	"X"[1] Inches	"Y"[1] Inches
46	VDD3	–3103.11	–486.00	–0.1221695	–0.0191339
47	VDDQ3	–3103.11	–344.16	–0.1221695	–0.0135496
48	DOUT6	–3103.11	–172.64	–0.1221695	–0.0067969
49	DOUT7	–3103.11	81.92	–0.1221695	0.0032252
50	DOUT8	–3103.11	293.92	–0.1221695	0.0115717
51	DOUT9	–3103.11	548.48	–0.1221695	0.0215937
52	PIXCLK	–3103.11	760.48	–0.1221695	0.0299402
53	DGND2	–3103.11	953.28	–0.1221695	0.0375307
54	FRAME_VALID	–3103.11	1146.08	–0.1221695	0.0451213
55	VDD2	–3103.11	1328.40	–0.1221695	0.0522992
56	VDDQ2	–3103.11	1470.24	–0.1221695	0.0578835
57	LINE_VALID	–3103.11	1641.76	–0.1221695	0.0646362
58	FLASH	–3103.11	1896.32	–0.1221695	0.0746583
59	EXTCLK	–3103.11	2108.32	–0.1221695	0.0830047
60	VDDPLL	–3103.11	2532.24	–0.1221695	0.0996945

Notes:
1. Reference to center of each bond pad from center of die (0, 0).
2. DNU = do not use. See "Bonding Instructions" on page 2.
3. Also referred to as XSHUTDOWN.
4. TEST pad must be tied to DGND for normal device operation.

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Die Features

Figure 3: Die Outline (Top View)

1 2 3 4 5 6 7 8 9 10 11 12 13

+Y
Pad 1 (Table 1) or
center of die (Table 2)
-X +X
-Y

60 59 58 57 56 55 54 53 52 51 50 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33

First clear pixel (col. 98, row 29)

Pixel Array

Die center
(0µm, 0µm)

Optical center
from die center
(127.40µm, –0.49µm)

Last clear pixel (col. 2,153, row 1,572)

32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14

Die ID: C16C
and logo location

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Physical Specifications

Table 3: Physical Dimensions

Feature	Dimensions
Wafer diameter	200mm (8in)
Die thickness	200µm ±12µm
Singulated die size (after wafer saw) *Width:* *Length:*	 6,512 ±25µm 6,620 ±25µm
Bond pad size (MIN)	85µm x 100µm (3.35 mil x 3.94 mil)
Passivation openings (MIN)	75µm x 90µm (2.95 mil x 3.54 mil)
Minimum bond pad pitch	131µm (5.157 mil)
Optical array *Optical center from die center:* *Optical center from center of pad 1:*	 X = 127.40µm, Y = –0.49µm X = 2,540.76µm, Y = –3,157.60µm
First clear pixel (col. 98, row 29) *From die center:* *From center of pad 1:*	 X = 2,388.12µm, Y = 1,696.83µm X = 4,801.48µm, Y = –1,460.27µm
Last clear pixel (col. 2,153, row 1,572) *From die center:* *From center of pad 1:*	 X = –2,133.32µm, Y = –1,697.82µm X = 280.04µm, Y = –4,854.92µm

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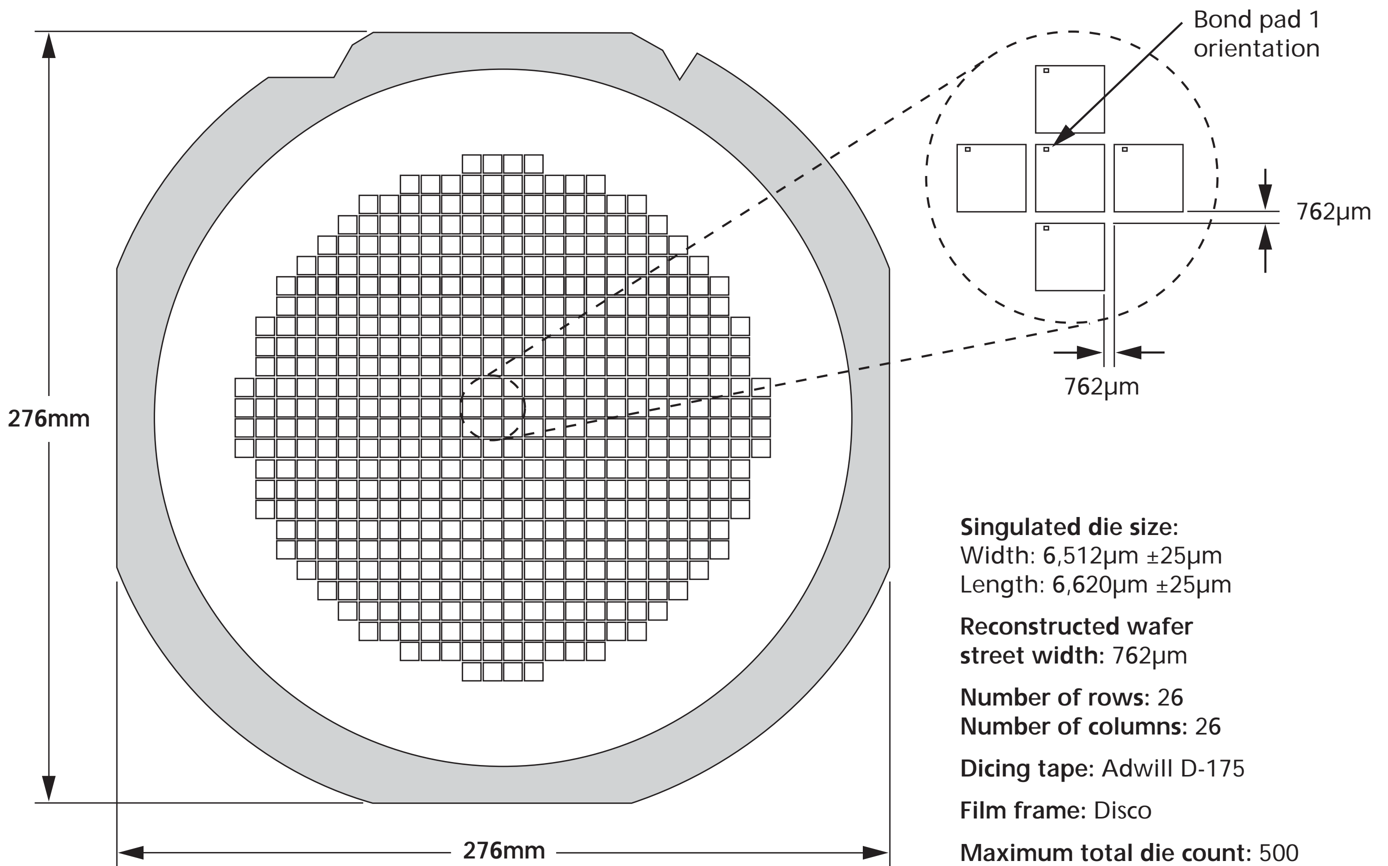
Figure 4: MT9T012 Die Orientation in Reconstructed Wafer



Singulated die size:
Width: 6,512µm ±25µm
Length: 6,620µm ±25µm

Reconstructed wafer street width: 762µm

Number of rows: 26
Number of columns: 26

Dicing tape: Adwill D-175

Film frame: Disco

Maximum total die count: 500

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Advance: This data sheet contains initial descriptions of products still under development.

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Revision History

Rev. C **7/07**

- Updated template

Rev. B **5/06**

- Changed chief ray angle from 17° to 21.36°

Rev. A **3/06**

- Initial release

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