

# GDDR5 SGRAM

## MT51J256M32 – 16 Meg x 32 I/O x 16 banks, 32 Meg x 16 I/O x 16 banks

### Features

- $V_{DD} = V_{DDQ} = 1.5V \pm 3\%$  and  $1.35V \pm 3\%$
- Data rate: 6.0 Gb/s, 7.0 Gb/s, 8.0 Gb/s
- 16 internal banks
- Four bank groups for  $t_{CCDL} = 3 t_{CK}$
- 8n-bit prefetch architecture: 256-bit per array read or write access for x32; 128-bit for x16
- Burst length (BL): 8 only
- Programmable CAS latency: 7–24
- Programmable WRITE latency: 4–7
- Programmable CRC READ latency: 2–3
- Programmable CRC WRITE latency: 8–14
- Programmable EDC hold pattern for CDR
- Precharge: Auto option for each burst access
- Auto refresh and self refresh modes
- Refresh cycles: 16,384 cycles/32ms
- Interface: Pseudo open drain (POD-15) compatible outputs: 40Ω pull-down, 60Ω pull-up
- On-die termination (ODT): 60Ω or 120Ω (NOM)
- ODT and output driver strength auto calibration with external resistor ZQ pin: 120Ω
- Programmable termination and driver strength off-sets
- Selectable external or internal  $V_{REF}$  for data inputs; programmable offsets for internal  $V_{REF}$
- Separate external  $V_{REF}$  for address/command inputs
- x32/x16 mode configuration set at power-up with EDC pin
- Single-ended interface for data, address, and command
- Quarter data rate differential clock inputs CK<sub>t</sub>, CK<sub>c</sub> for address and commands
- Two half data rate differential clock inputs, WCK<sub>t</sub> and WCK<sub>c</sub>, each associated with two data bytes (DQ, DBI<sub>n</sub>, EDC)
- DDR data (WCK) and addressing (CK)
- SDR command (CK)
- Write data mask function via address bus (single/double byte mask)
- Data bus inversion (DBI) and address bus inversion (ABI)
- Digital RAS lockout

- Address training: Address input monitoring via DQ pins
- WCK2CK clock training: Phase information via EDC pins
- Data read and write training via read FIFO (FIFO depth = 6)
- Read FIFO pattern preloaded by LDFF command
- Direct write data load to read FIFO by WRTR command
- Consecutive read of read FIFO by RDTR command
- Read/write data transmission integrity secured by cyclic redundancy check (CRC-8)
- Read/write EDC on/off mode
- Low power modes
- RDQS mode on EDC pin
- On-die temperature sensor with readout
- Automatic temperature sensor controlled self refresh rate
- Vendor ID, FIFO depth and density info fields for identification
- Mirror function with MF pin
- Boundary scan function with SEN pin
- Lead-free (RoHS-compliant) and halogen-free packaging
- $T_C = 0^\circ\text{C}$  to  $+95^\circ\text{C}$

### Options<sup>1</sup>

- Organization
  - 256 Meg x 32 (words x bits)
- FBGA package
  - 170-ball (12mm x 14mm)
- Timing – maximum data rate
  - 6.0 Gb/s, 5.0 Gb/s
  - 7.0 Gb/s, 6.0 Gb/s
  - 8.0 Gb/s, 6.0 Gb/s
- Operating temperature
  - Commercial ( $0^\circ\text{C} \leq T_C \leq +95^\circ\text{C}$ )
- Revision

### Marking

|        |
|--------|
| 256M32 |
| HF     |
| -60    |
| -70    |
| -80    |
| None   |
| A      |

Note: 1. Not all options listed can be combined to define an offered product. Use the part catalog search on <http://www.micron.com> for available offerings.



## Ball Assignments and Descriptions

**Figure 2: 170-Ball FBGA – MF = 0 (Top View)**

|   | 1                | 2                | 3                | 4                | 5                | 6 | 7 | 8 | 9 | 10                | 11               | 12               | 13               | 14                |
|---|------------------|------------------|------------------|------------------|------------------|---|---|---|---|-------------------|------------------|------------------|------------------|-------------------|
| A | V <sub>SSQ</sub> | DQ1              | V <sub>SSQ</sub> | DQ0              | NC               |   |   |   |   | V <sub>REFD</sub> | DQ8              | V <sub>SSQ</sub> | DQ9              | V <sub>SSQ</sub>  |
| B | V <sub>DDQ</sub> | DQ3              | V <sub>DDQ</sub> | DQ2              | V <sub>SS</sub>  |   |   |   |   | V <sub>SS</sub>   | DQ10             | V <sub>DDQ</sub> | DQ11             | V <sub>DDQ</sub>  |
| C | V <sub>SSQ</sub> | EDC0             | V <sub>SSQ</sub> | V <sub>SSQ</sub> | V <sub>DD</sub>  |   |   |   |   | V <sub>DD</sub>   | V <sub>SSQ</sub> | V <sub>SSQ</sub> | EDC1             | V <sub>SSQ</sub>  |
| D | V <sub>DDQ</sub> | DBI0_n           | V <sub>DDQ</sub> | WCK01_t          | WCK01_c          |   |   |   |   | V <sub>SS</sub>   | V <sub>DD</sub>  | V <sub>DDQ</sub> | DBI1_n           | V <sub>DDQ</sub>  |
| E | V <sub>SSQ</sub> | DQ5              | V <sub>SSQ</sub> | DQ4              | V <sub>DDQ</sub> |   |   |   |   | V <sub>DDQ</sub>  | DQ12             | V <sub>SSQ</sub> | DQ13             | V <sub>SSQ</sub>  |
| F | V <sub>DDQ</sub> | DQ7              | V <sub>DDQ</sub> | DQ6              | V <sub>SSQ</sub> |   |   |   |   | V <sub>SSQ</sub>  | DQ14             | V <sub>DDQ</sub> | DQ15             | V <sub>DDQ</sub>  |
| G | V <sub>DD</sub>  | V <sub>DDQ</sub> | RAS_n            | V <sub>DD</sub>  | V <sub>SS</sub>  |   |   |   |   | V <sub>SS</sub>   | V <sub>DD</sub>  | CS_n             | V <sub>DDQ</sub> | V <sub>DD</sub>   |
| H | V <sub>SS</sub>  | V <sub>SSQ</sub> | V <sub>DDQ</sub> | A10, A0          | A9, A1           |   |   |   |   | BA3, A3           | BA0, A2          | V <sub>DDQ</sub> | V <sub>SSQ</sub> | V <sub>SS</sub>   |
| J | MF               | RESET_n          | CKE_n            | AB1_n            | A12, A13         |   |   |   |   | SEN               | CK_c             | CK_t             | ZQ               | V <sub>REFC</sub> |
| K | V <sub>SS</sub>  | V <sub>SSQ</sub> | V <sub>DDQ</sub> | A8, A7           | A11, A6          |   |   |   |   | BA1, A5           | BA2, A4          | V <sub>DDQ</sub> | V <sub>SSQ</sub> | V <sub>SS</sub>   |
| L | V <sub>DD</sub>  | V <sub>DDQ</sub> | CAS_n            | V <sub>DD</sub>  | V <sub>SS</sub>  |   |   |   |   | V <sub>SS</sub>   | V <sub>DD</sub>  | WE_n             | V <sub>DDQ</sub> | V <sub>DD</sub>   |
| M | V <sub>DDQ</sub> | DQ31             | V <sub>DDQ</sub> | DQ30             | V <sub>SSQ</sub> |   |   |   |   | V <sub>SSQ</sub>  | DQ22             | V <sub>DDQ</sub> | DQ23             | V <sub>DDQ</sub>  |
| N | V <sub>SSQ</sub> | DQ29             | V <sub>SSQ</sub> | DQ28             | V <sub>DDQ</sub> |   |   |   |   | V <sub>DDQ</sub>  | DQ20             | V <sub>SSQ</sub> | DQ21             | V <sub>SSQ</sub>  |
| P | V <sub>DDQ</sub> | DBI3_n           | V <sub>DDQ</sub> | WCK23_t          | WCK23_c          |   |   |   |   | V <sub>SS</sub>   | V <sub>DD</sub>  | V <sub>DDQ</sub> | DBI2_n           | V <sub>DDQ</sub>  |
| R | V <sub>SSQ</sub> | EDC3             | V <sub>SSQ</sub> | V <sub>SSQ</sub> | V <sub>DD</sub>  |   |   |   |   | V <sub>DD</sub>   | V <sub>SSQ</sub> | V <sub>SSQ</sub> | EDC2             | V <sub>SSQ</sub>  |
| T | V <sub>DDQ</sub> | DQ27             | V <sub>DDQ</sub> | DQ26             | V <sub>SS</sub>  |   |   |   |   | V <sub>SS</sub>   | DQ18             | V <sub>DDQ</sub> | DQ19             | V <sub>DDQ</sub>  |
| U | V <sub>SSQ</sub> | DQ25             | V <sub>SSQ</sub> | DQ24             | NC               |   |   |   |   | V <sub>REFD</sub> | DQ16             | V <sub>SSQ</sub> | DQ17             | V <sub>SSQ</sub>  |

(Top view)



Note: 1. Balls shown with a heavy, solid outline are off in x16 mode.

**Figure 3: 170-Ball FBGA – MF = 1 (Top View)**

|   | 1                | 2                | 3                | 4                | 5                | 6 | 7 | 8 | 9 | 10                | 11               | 12               | 13               | 14                |
|---|------------------|------------------|------------------|------------------|------------------|---|---|---|---|-------------------|------------------|------------------|------------------|-------------------|
| A | V <sub>SSQ</sub> | DQ25             | V <sub>SSQ</sub> | DQ24             | NC               |   |   |   |   | V <sub>REFD</sub> | DQ16             | V <sub>SSQ</sub> | DQ17             | V <sub>SSQ</sub>  |
| B | V <sub>DDQ</sub> | DQ27             | V <sub>DDQ</sub> | DQ26             | V <sub>SS</sub>  |   |   |   |   | V <sub>SS</sub>   | DQ18             | V <sub>DDQ</sub> | DQ19             | V <sub>DDQ</sub>  |
| C | V <sub>SSQ</sub> | EDC3             | V <sub>SSQ</sub> | V <sub>SSQ</sub> | V <sub>DD</sub>  |   |   |   |   | V <sub>DD</sub>   | V <sub>SSQ</sub> | V <sub>SSQ</sub> | EDC2             | V <sub>SSQ</sub>  |
| D | V <sub>DDQ</sub> | DBI3_n           | V <sub>DDQ</sub> | WCK23_t          | WCK23_c          |   |   |   |   | V <sub>SS</sub>   | V <sub>DD</sub>  | V <sub>DDQ</sub> | DBI2_n           | V <sub>DDQ</sub>  |
| E | V <sub>SSQ</sub> | DQ29             | V <sub>SSQ</sub> | DQ28             | V <sub>DDQ</sub> |   |   |   |   | V <sub>DDQ</sub>  | DQ20             | V <sub>SSQ</sub> | DQ21             | V <sub>SSQ</sub>  |
| F | V <sub>DDQ</sub> | DQ31             | V <sub>DDQ</sub> | DQ30             | V <sub>SSQ</sub> |   |   |   |   | V <sub>SSQ</sub>  | DQ22             | V <sub>DDQ</sub> | DQ23             | V <sub>DDQ</sub>  |
| G | V <sub>DD</sub>  | V <sub>DDQ</sub> | CAS_n            | V <sub>DD</sub>  | V <sub>SS</sub>  |   |   |   |   | V <sub>SS</sub>   | V <sub>DD</sub>  | WE_n             | V <sub>DDQ</sub> | V <sub>DD</sub>   |
| H | V <sub>SS</sub>  | V <sub>SSQ</sub> | V <sub>DDQ</sub> | A8, A7           | A11, A6          |   |   |   |   | BA1, A5           | BA2, A4          | V <sub>DDQ</sub> | V <sub>SSQ</sub> | V <sub>SS</sub>   |
| J | MF               | RESET_n          | CKE_n            | ABI_n            | A12, A13         |   |   |   |   | SEN               | CK_c             | CK_t             | ZQ               | V <sub>REFC</sub> |
| K | V <sub>SS</sub>  | V <sub>SSQ</sub> | V <sub>DDQ</sub> | A10, A0          | A9, A1           |   |   |   |   | BA3, A3           | BA0, A2          | V <sub>DDQ</sub> | V <sub>SSQ</sub> | V <sub>SS</sub>   |
| L | V <sub>DD</sub>  | V <sub>DDQ</sub> | RAS_n            | V <sub>DD</sub>  | V <sub>SS</sub>  |   |   |   |   | V <sub>SS</sub>   | V <sub>DD</sub>  | CS_n             | V <sub>DDQ</sub> | V <sub>DD</sub>   |
| M | V <sub>DDQ</sub> | DQ7              | V <sub>DDQ</sub> | DQ6              | V <sub>SSQ</sub> |   |   |   |   | V <sub>SSQ</sub>  | DQ14             | V <sub>DDQ</sub> | DQ15             | V <sub>DDQ</sub>  |
| N | V <sub>SSQ</sub> | DQ5              | V <sub>SSQ</sub> | DQ4              | V <sub>DDQ</sub> |   |   |   |   | V <sub>DDQ</sub>  | DQ12             | V <sub>SSQ</sub> | DQ13             | V <sub>SSQ</sub>  |
| P | V <sub>DDQ</sub> | DBI0_n           | V <sub>DDQ</sub> | WCK01_t          | WCK01_c          |   |   |   |   | V <sub>SS</sub>   | V <sub>DD</sub>  | V <sub>DDQ</sub> | DBI1_n           | V <sub>DDQ</sub>  |
| R | V <sub>SSQ</sub> | EDC0             | V <sub>SSQ</sub> | V <sub>SSQ</sub> | V <sub>DD</sub>  |   |   |   |   | V <sub>DD</sub>   | V <sub>SSQ</sub> | V <sub>SSQ</sub> | EDC1             | V <sub>SSQ</sub>  |
| T | V <sub>DDQ</sub> | DQ3              | V <sub>DDQ</sub> | DQ2              | V <sub>SS</sub>  |   |   |   |   | V <sub>SS</sub>   | DQ10             | V <sub>DDQ</sub> | DQ11             | V <sub>DDQ</sub>  |
| U | V <sub>SSQ</sub> | DQ1              | V <sub>SSQ</sub> | DQ0              | NC               |   |   |   |   | V <sub>REFD</sub> | DQ8              | V <sub>SSQ</sub> | DQ9              | V <sub>SSQ</sub>  |

(Top view)



Note: 1. Balls shown with a heavy, solid outline are off in x16 mode.

**Table 1: 170-Ball FBGA Ball Descriptions**

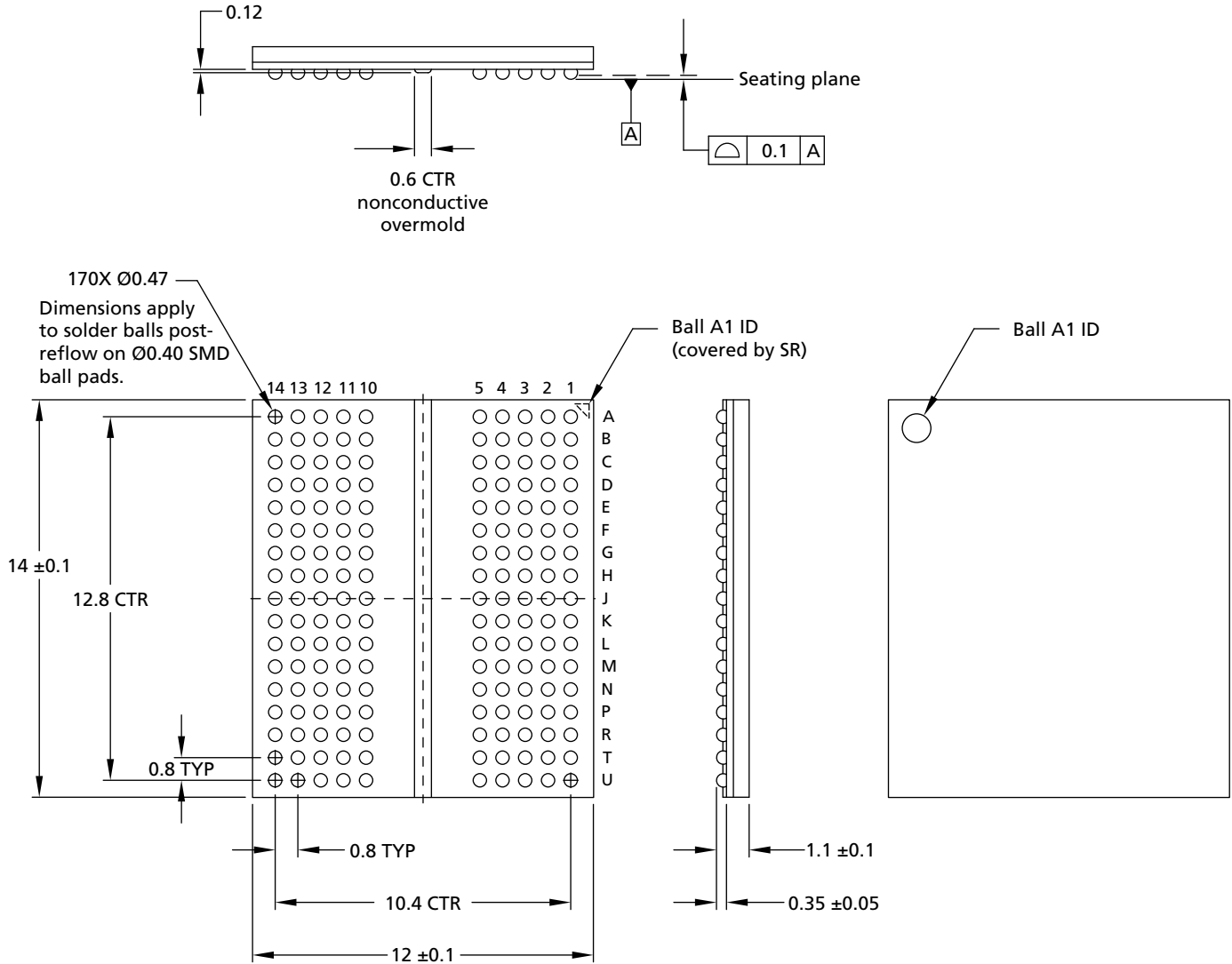
| Symbol                                | Type  | Description  |
|---------------------------------------|-------|--|
| A[13:0]                               | Input | <b>Address inputs:</b> Provide the row address for ACTIVE commands. A[6:0] (A7) provide the column address and A8 defines the auto precharge bit for READ/WRITE commands, to select one location out of the memory array in the respective bank. A8 sampled during a PRECHARGE command determines whether the PRECHARGE applies to one bank (A8 LOW, bank selected by BA[3:0]) or all banks (A8 HIGH). The address inputs also provide the op-code during a MODE REGISTER SET command and the data bits during LDFF commands. A[12:8] are sampled with the rising edge of CK_t and A[7:0], A13 are sampled with the rising edge of CK_c.   |
| ABI_n                                 | Input | <b>Address bus inversion:</b> Reduces the power requirements on address pins by limiting the number of address lines driving LOW to 5. ABI_n is enabled by the corresponding ABI mode register bit.  |
| BA[3:0]                               | Input | <b>Bank address inputs:</b> Define the bank to which an ACTIVE, READ, WRITE, or PRECHARGE command is being applied. BA[3:0] define which mode register is loaded during the MODE REGISTER SET command. BA[3:0] are sampled with the rising edge of CK_t.   |
| CK_t, CK_c                            | Input | <b>Clock:</b> CK_t and CK_c are differential clock inputs. Command inputs are latched on the rising edge of CK_t. Address inputs are latched on the rising edge of CK_t and the rising edge of CK_c. All latencies are referenced to CK_t. CK_t and CK_c are externally terminated.  |
| WCK01_t, WCK01_c/<br>WCK23_t, WCK23_c | Input | <b>Data Clocks:</b> WCK_t and WCK_c are differential clocks used for write data capture and read data output. WCK01_t and WCK01_c are associated with DQ[15:0], DBI0_n, DBI1_n, EDC0, and EDC1. WCK23_t and WCK23_c are associated with DQ[31:16], DBI2_n, DBI3_n, EDC2, and EDC3. WCK clocks operate at nominally twice the CK clock frequency.   |
| CKE_n                                 | Input | <b>Clock enable:</b> CKE_n enables (registered LOW) and disables (registered HIGH) internal circuitry and clocks on the device. The specific circuitry that is enabled/disabled is dependent upon the device configuration and operating mode. Taking CKE_n HIGH provides PRECHARGE POWER-DOWN and SELF REFRESH operations (all banks idle), or active power-down (row active in any bank). CKE_n is synchronous for power-down entry and exit and for self refresh entry. CKE_n must be maintained LOW throughout read and write accesses. Input buffers (excluding CKE_n) are disabled during SELF REFRESH operation. The value of CKE_n latched at power-up with RESET_n going HIGH determines the termination value of the address and command inputs. |
| CS_n                                  | Input | <b>Chip select:</b> CS_n enables (registered LOW) and disables (registered HIGH) the command decoder. All commands are masked when CS_n is registered HIGH, but internal command execution continues. CS_n is considered part of the command code.   |
| MF                                    | Input | <b>Mirror function:</b> V <sub>DDQ</sub> CMOS input. Must be tied to V <sub>DDQ</sub> or V <sub>SS</sub> .   |
| RAS_n, CAS_n, WE_n                    | Input | <b>Command inputs:</b> RAS_n, CAS_n, and WE_n (along with CS_n) define the command being entered.  |
| RESET_n                               | Input | <b>Reset:</b> RESET_n is an active LOW CMOS input referenced to V <sub>SS</sub> . A full chip reset may be performed at any time by pulling RESET_n LOW. With RESET_n LOW all ODTs are disabled.   |
| SEN                                   | Input | <b>Scan enable:</b> V <sub>DDQ</sub> CMOS input. Must be tied to V <sub>SS</sub> when not in use.  |

**Table 1: 170-Ball FBGA Ball Descriptions (Continued)**

| Symbol            | Type      | Description   |
|-------------------|-----------|---|
| DQ[31:0]          | I/O       | <b>Data input/output:</b> Bidirectional 32-bit data bus.  |
| DBI[3:0]_n        | I/O       | <b>Data bus inversion:</b> Reduces the DC power consumption and supply noise induced jitter on data pins. DBI0_n is associated with DQ[7:0], DBI1_n with DQ[15:8], DBI2_n with DQ[23:16], and DBI3_n with DQ[31:24].  |
| EDC[3:0]          | Output    | <b>Error detection code:</b> The calculated CRC data is transmitted on these pins. In addition, these pins drive a hold pattern when idle and can be used as an RDQS function. EDC0 is associated with DQ[7:0], EDC1 with DQ[15:8], EDC2 with DQ[23:16], and EDC3 with DQ[31:24]. |
| V <sub>DD</sub>   | Supply    | <b>Power supply:</b> 1.5V ±3% and 1.35V ±3%.  |
| V <sub>DDQ</sub>  | Supply    | <b>DQ power supply:</b> 1.5V ±3% and 1.35V ±3%. Isolated on the device for improved noise immunity.   |
| V <sub>REFC</sub> | Supply    | <b>Reference voltage for control and address:</b> V <sub>REFC</sub> must be maintained at all times (including self refresh) for proper device operation.   |
| V <sub>REFD</sub> | Supply    | <b>Reference voltage for data:</b> V <sub>REFD</sub> must be maintained at all times (including self refresh) for proper device operation.  |
| V <sub>SS</sub>   | Supply    | Ground.   |
| V <sub>SSQ</sub>  | Supply    | <b>DQ ground:</b> Isolated on the device for improved noise immunity.   |
| ZQ                | Reference | <b>External reference ball for impedance calibration:</b> This ball is tied to an external 120Ω resistor (ZQ), which is tied to V <sub>SSQ</sub> .  |
| NC                | –         | <b>No connect:</b> These balls should be left unconnected (the ball has no connection to the device or to other balls).   |

## Package Dimensions

**Figure 4: 170-Ball FBGA (BG)**



- Notes: 1. All dimensions are in millimeters.  
2. Solder ball material: SAC-Q (92.5% Sn, 4% Ag, 3% Bi, 0.5% Cu).

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This data sheet contains minimum and maximum limits specified over the power supply and temperature range set forth herein. Although considered final, these specifications are subject to change, as further product development and data characterization sometimes occur.