Q. What are the latest technologies used to improve image quality for CMOS sensors?

A. As camera phones become the most relied upon technology for impromptu photos, image quality has become an increasingly important factor when selecting a camera phone or other mobile device. Three key technologies are driving image sensor image quality: Backside illumination (BSI), Color Noise Reduction (CNR) and High Dynamic Range (HDR). These technologies are successful in improving image quality, reducing color noise for brighter and more vibrant colors and delivering critical detail in both light and dark areas. Toshiba is combining these technologies for even greater impact and image quality improvement.

- BSI supports the trend towards higher resolution cameras and smaller pixels by enabling image sensors to have substantially increased light sensitivity. A smaller pixel reduces the amount of light that can be captured by the photodiodes. BSI deploys a lens on the silicon substrate behind the sensor and not on front where the wiring interferes with the light absorption. Backside positioning boosts light sensitivity and absorption by 40 percent compared to conventional technologies, and allows formation of finer image pixels.

- Color noise reduction separates the image into low, middle and high spatial frequencies. Components of the low and middle frequency are used to decrease the color noise and are combined into a color noise reduction map. The output image is then made by combining color components of the high spatial frequency (HSF) image with the color noise reduction map. The luminance data from the source image is preserved in the HSF image as it is passed on to the output image.

- High dynamic range (HDR) technology delivers better image quality and brighter, truer colors by accurately representing the wide range of intensity levels found in direct sunlight and in the deepest shadows. Non-HDR cameras take pictures at one exposure level with limited contrast range, which results in the loss of detail in the bright or dark areas of a picture, depending on the setting of the camera. HDR compensates for this loss of detail by taking multiple pictures at different exposure levels and intelligently stitching them together to produce a picture that is representative in both dark and bright area. Toshiba uses an alternate row, dual exposure HDR that not only improves the dynamic range, but also reduces motion artifacts and eliminates frame buffer requirements without compromising frame resolution or speed.
Q. What is being done to support the demands for thinner camera phones and mobile devices?
A. As camera phones become thinner and thinner, new technologies and innovative packaging are being employed to reduce camera height. Yet achieving today’s high-resolution CMOS image sensors requires a larger optical size for corresponding lenses which results in a thicker camera module and a bulkier mobile device. Conventional methods of modifying the optical lens design are problematic due to resolution drop around the corners of the image area.

Toshiba resolves this drop in resolution with the use of an image pre-processing LSI (companion) chip that provides distortion correction and performs image resolution reconstruction, thus avoiding the need for a thicker module and bulkier device.(1)

Q. What are the primary mobile applications for CMOS image sensors?
A. The volume of digital photos people are snapping today using their camera phones has dramatically reshaped the entire digital imaging ecosystem. Image sensors are at the heart of smartphones, camera phones, tablets and laptops. Growth in CMOS Image Sensors is expected to have an expected CAGR of 5.1% over the next five years (2012-2017)(2).

Q. What CMOS image sensors does Toshiba offer for mobile applications?
A. Toshiba offers a family of products with some featuring HDR, BSI and CNR, with resolutions from 720p to 13MP, speeds up to 120 fps in VGA mode and pixel pitch from 1.75 microns to 1.12 microns. (See chart)

Q. Does Toshiba offer complete solutions?
A. Toshiba works with a variety of module manufacturers and integrators to provide a module solution to its customers.

Q. What is Toshiba’s background in image sensor technology?
A. Toshiba is a pioneer and world leader in image sensor technology both for charged-coupled devices (CCDs) and complementary metal oxide semiconductor (CMOS) image sensors. Toshiba’s leadership advancement and technology refinement during 20 plus years of designing, developing and manufacturing image sensors includes over 12 years in the specific development of CMOS image sensors, the heart of the camera phone and other mobile products and applications.

Toshiba’s market strength in image sensor-based camera applications is based on superior high-definition image quality, consistently innovative products and on the strong relationships forged with top-tier companies. Tight engineering and procurement team relationships, as well as superior “Benchmark” customer service have become the hallmark of Toshiba.
### Product Chart

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>SPEED</th>
<th>MORE FEATURES</th>
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| **T4K37 CMOS IMAGE SENSOR**                      | 30 fps @ full resolution, 60 fps @ 1080p, 60 fps @ 720p, 120 fps @ VGA | - BSI, HDR  
- CSI-2 4 lanes  
- Built-in PLL  
- Picture flip  
- Context switch  
- Strobe timing pulse  
- Progressive scan  
- Binning: Horizontal 1/2  
- Vertical 1/2, 1/4  
- Lens shading correction  
- 2nd PLL for CSI-2 output  
- Standby mode, power down mode  
- PC interface  
- Window of interest  
- Image scaling  
- Defect pixel correction  
- Global reset for mechanical shutter  
- OTP (8k bits) |
| **T4K04 CMOS IMAGE SENSOR**                      | 30 fps @ full resolution, 60 fps @ 1080p, 60 fps @ 720p, 120 fps @ VGA | - BSI  
- 4 lanes of CSI-2 output  
- Built-in PLL  
- Picture flip  
- Standby mode, power down mode  
- Progressive scan  
- Binning: Horizontal 1/2  
- Vertical 1/2, 1/4, 1/8  
- Global reset for mechanical shutter  
- OTP (4k bits)  
- PC interface  
- Lens shading correction  
- Defect pixel correction  
- Strobe timing pulse  
- Built-in regulator (1.8V to 1.2V) |
| **T4K35 CMOS IMAGE SENSOR**                      | 30 fps @ full resolution, 60 fps @ 1080p, 60 fps @ 720p, 120 fps @ VGA | - BSI and HDR  
- CSI-2 4 lanes  
- Built-in PLL  
- Image scaling  
- Lens shading correction  
- Global reset for mechanical shutter  
- OTP (8k bits)  
- PC interface  
- Built-in PLL  
- Image scaling  
- Picture flip  
- Defect pixel correction  
- Strobe timing pulse  
- Standby mode, power down mode |
| **T4K39 CMOS IMAGE SENSOR**                      | 15 fps @ full resolution, 30 fps @ 1080P (center cropped), 30 fps @ 720P, 60 fps @ VGA | - Progressive scan  
- 8-bit parallel output  
- Lens shading correction  
- Window of interest  
- Built-in PLL  
- Auto White Balance (AWB)  
- Auto flicker detection and correction  
- Edge enhancement  
- Built-in regulator (1.8V to 1.5V)  
- PC interface  
- Binning: Horizontal 1/2  
- Vertical 1/2, 1/4, 1/8  
- Image scaling  
- Picture effects (monochrome, negative, sepia, antique, sketch, emboss)  
- Gamma correction  
- Fake color reduction  
- Noise reduction  
- Standby mode, power down mode  
- CSI-2 2 lanes  
- Defect pixel correction  
- Picture flip  
- Digital zoom  
- Auto exposure (AE)  
- Built-in PLL  
- Programmable gamma correction  
- Flicker correction  
- Built-in regulator (1.8V to 1.5V) |
| **T4K28 CMOS IMAGE SENSOR**                      | 15 fps @ full resolution, 30 fps @ 1080P (center cropped), 60 fps @ 720P, 60 fps @ VGA | - Progressive scan  
- 8-bit parallel output  
- Window of interest  
- Picture flip  
- PC interface  
- Binning: Vertical 1/2  
- Image size  
- Picture effects (monochrome, negative, sepia, antique, sketch, emboss)  
- CSI-2 1 lane  
- Built-in PLL  
- Digital zoom  
- Auto luminance control  
- Built-in PLL  
- Programmable gamma correction  
- Flicker correction  
- Built-in regulator (1.8V to 1.5V) |
| **T4K24 CMOS IMAGE SENSOR**                      | 30 fps @ 1080P, 30 fps @ 720P, 60 fps @ VGA | - Progressive scan  
- Binning: Horizontal 1/2  
- Vertical 1/2  
- Standby mode, power down mode  
- PC interface  
- Lens shading correction  
- Defect pixel correction  
- OTP (4k bits)  
- CSI-2 1 lane  
- Built-in PLL  
- Picture flip (horizontal and vertical)  
- Built-in regulator (1.8V to 1.5V) |
| **T4K08 CMOS IMAGE SENSOR**                      | 30 fps @ 720P, 60 fps @ VGA | - Progressive scan  
- Binning: Horizontal 1/2  
- Vertical 1/2  
- Standby mode, power down mode  
- PC interface  
- Lens shading correction  
- Defect pixel correction  
- Auto Exposure (AE)  
- Picture flip  
- 1 lane of CSI-2 output  
- Auto White Balance (AWB)  
- Standby mode, power down mode |
| **T4K71 CMOS IMAGE SENSOR**                      | 1080P 60 fps @ Full-FOV, 720P, 60 fps @ Full-FOV VGA, 100 fps | - CNR, BSI  
- CSI-2 2 lanes  
- Picture flip  
- Standby mode, power down mode  
- Progressive scan  
- Built-in PLL  
- Lens shading correction  
- PC interface  
- Image scaling  
- Auto-defect pixel correction |

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Resolution reconstruction adopted for this new product is a super-reconstruction technology developed by Toshiba corporate research and development center.

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