ReThink Consumer Electronics with Crossbar ReRAM technology

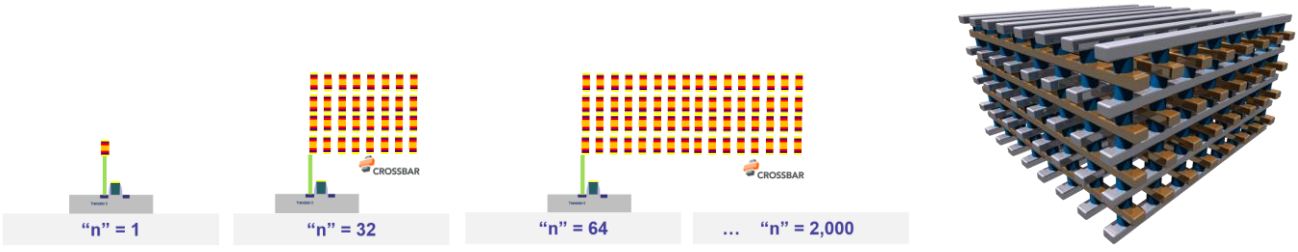
Consumers create, access and distribute enormous quantities of rich multimedia every day and expect to stream and enjoy that content instantly on their tablets, set-top boxes, gaming systems, and televisions. Innovations in high-resolution displays drive demand for high-capacity storage solutions. A 4K Ultra High Definition TV integrates 4X more pixels compared to 1080p Full HD displays. The next generation 8K high-resolution displays have more than 33 Megapixels per frame, requiring 100 Mbytes of storage for a single raw picture. This massive increase of multimedia file size is revolutionizing the physical media storage industry as a 2hr movie in 4K resolution is facing challenges to fit in current Blu-Ray optical disks.

Even with the most advanced compression algorithms, high-definition multimedia content requires huge bandwidth to be written and read without pre-buffering. The end-user experience will suffer from the inherent latencies introduced by the design and physics

constraints of optical disks and NAND-Flash based Solid-State Drives. NAND Flash faces challenges to scale to 1TByte high capacity in low process node of device manufacturing due to Flash electron physical limitation. The program operation is slow and done at the granularity of a large page size. NAND Flash has to be erased prior to being programmed. The NAND erase operation is slow, in the 10ms range, and is done for a very large block size, 4-8Mbytes. This is a challenge for consumer electronics whose users frequently access high-definition multimedia and download/upload content to the cloud. The Solid-State storage industry has to re-invent the way we store and distribute physical multi-media content.

Crossbar's ReRAM memory technology answers the challenges of high-resolution displays and high-definition multimedia content in consumer electronics by delivering 100X lower read latency, 1000x faster write performance, 2x high density, and 20x lower power consumption than today's best-in-class 3D NAND Flash memory. Compared with traditional NAND or SPI NOR Flash, Crossbar ReRAM is bit/byte-alterable, erase-free operation, and doesn't have the Flash design constraint to build memory arrays in large blocks. Crossbar's ReRAM technology can be architected with smaller pages (e.g. 256Byte pages vs. 16KByte pages in NAND) that can be independently re-programmed. This new storage architecture drastically simplifies the complexity of the storage controller by removing a large portion of the background memory accesses required for garbage collection. Also, the erase-free architecture with small page granularity that can be re-programmed without a block erase provides an impressive performance boost over Flash-based storage solutions. Crossbar's ReRAM technology is simplifying the management of data writes and reads by a simple storage controller, not only improving the performance and overall endurance of the data storage solution but also reducing the overall power consumption of data manipulation in consume electronics.

With Crossbar's patented selector, one of the greatest technical challenges of high-density ReRAM is solved. Thousands of Crossbar's ReRAM cells can be interconnected in true cross-point memory arrays, enabling cells to be 3D stackable. This selector feature provides a significant advantage in lowering the cost per gigabit and improving the array efficiency. Compared with planar NAND Flash, 3D ReRAM is 10x denser; compared with 3D NAND Flash, 3D ReRAM is 2x denser.



Crossbar's ReRAM cell operation is based on the storage of a metallic filament in a non-conductive layer, with potential to scale below 10nm process without impacting the performance. Crossbar's simple ReRAM cell structure makes it very easy and cost-efficient

to integrate ReRAM arrays in back-end-of-line (BEOL) in between metal layers, creating the opportunity to integrate CMOS logic and 3D ReRAM storage in a single die. Also, the standard CMOS BEOL integration not only reduces manufacturing cost (estimated to be 32% lower per die than Flash), but also makes it more flexible to work with different chip companies to design and fabricate embedded solutions. The embedded or standalone storage solutions offer more flexibility for storing multimedia data with high performance, low latency, low power consumption characteristics.

The security of consumer electronics systems are becoming a risk. Integrating ReRAM memory on the chip enhances the system security and enables the great possibility to build more robust and secure Digital Right Management (DRM) protected media storage solutions.

Security Threats	Recommendations	Crossbar ReRAM Advantages on security
External memory bus snooping	Sensitive code and data should never be exposed outside of the SoC package	ReRAM integrated with logic CMOS scales to advanced process nodes.
Software attacks to unlock chain of trust	No backdoor. Implement cryptographic, hashing techniques to guaranty integrity and authenticity of boot code, OS and applications. Use true One-Time Programmable	Specific ReRAM program algorithms enabling OTP capabilities in the same array
Physical attacks to read confidential data	Robust layout to prevent memory cell value extraction	ReRAM cell is vertical with very small cross-section making it very hard to measure resistance value

By leveraging ReRAM technology, smaller, faster, more secure and energy efficient SoCs are creating opportunities to differentiate in consumer electronics applications.

ReRAM Key Attributes for Consumer Electronics Applications:

By offering high performance, high capacity storage solutions, Crossbar ReRAM memory technology provides the best experience of next generation Ultra UHD content on DTVs, set top boxes, and home gateways.