

ReThink ReRAM For Use as FTP or OTP Memory

CrossBar Resistive RAM (ReRAM) is a non-volatile memory (NVM) that can be integrated into any complementary metal-oxide semiconductor (CMOS) semiconductor process. In addition to its High-Performance, High-Density NVM multiple-time programmable (MTP) memories, CrossBar NVM can also be utilized in highly secure few-time programmable (FTP) or one-time programmable (OTP) applications.

BACKGROUND

Three types of embedded NVM are utilized in CMOS semiconductor applications depending on how many times the NVM needs be written. These include: 1) MTP, 2) FTP and 3.) OTP memories. While OTP memory can only be written once, FTP memory can typically be written 100 times and MTP memory 10,000 to 1,000,000 times. While some unique semiconductor codes like trim bits and program/boot code may need to be written only once at manufacture or setup time, software code could need to be updated occasionally and data storage be written millions of times. These memory requirements vary by application type. CrossBar's ReRAM NVM can address the needs of MTP, FTP and OTP applications, even below 28nm foundry nodes where traditional eFlash cannot be manufactured.

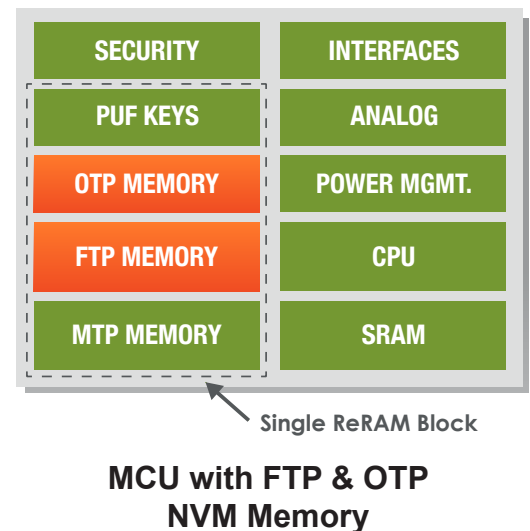
FTP MEMORY

FTP embedded memories capable of being written 100 or more times often use floating gate technology. While flash memory can be utilized at larger foundry nodes, it does not scale below 28 nm. CrossBar's FTP memory is based on its unique ReRAM technology which can be ported below 28nm and is currently being implemented at 12nm with a demonstrable path to even smaller foundry geometries. CrossBar's ReRAM MTP/FTP technology supports up to 1,000,000 writes. The company is also planning on a cost reduced FTP version of its ReRAM technology optimized for about 100 writes, consuming only about half the silicon cell area as its ReRAM MTP counterpart.

OTP MEMORY

OTP operates as NVM but can only be written once to store fixed microcode, set calibration/trim bits or other chip ID parameters. Whether using electrical fuse or anti-fuse OTP technology, OTP memory, once written cannot be modified. While OTP memory may consume relatively small die area, OTP technologies often have disadvantages such as, write once limitations causing difficulty detecting memory defects, requirements for special programming equipment and circuitry, long write or read times, difficulty with random access prior to programming, high programming voltage, high leakage current in standby mode, limited temperature range, as well as single bit OTP memory lockup (entire OTP macro cannot be written after 1 bit is written).

CrossBar's non-volatile high-performance ReRAM memory can also be used for OTP applications. Since ReRAM has the capability of being written multiple times, many of the issues associated with OTP memory disappear.





CROSSBAR ReRAM FTP AND OTP MEMORY

CrossBar has two versions of its ReRAM FTP and OTP technology: 1) ReRAM MTP compatible FTP and OTP memories, and is planning a 2) Custom FTP/OTP for higher density and shorter write times. ReRAM MTP compatible FTP/OTP memories use the same ReRAM cell as CrossBar's high-performance MTP in a single monolithic ReRAM memory. Because of this compatibility, the same memory and controller can be shared between standard MTP memory as well as FTP/OTP applications. This MTP memory can be written 100,000 to 1,000,000 times. In this case, MTP, FTP, and OTP as well as physical unclonable function (PUF) keys can be flexibly partitioned within the same common ReRAM memory. In addition, CrossBar is planning an optimized ReRAM memory cell designed specifically for lower endurance FTP and OTP applications. This optimized version of FTP/OTP ReRAM memory is expected to result in significantly smaller die area and lower cost when larger amounts of embedded FTP and OTP memory storage are required (KBytes to MBytes).

For example, a CrossBar MTP/OTP ReRAM memory optimized for a maximum of about 100 writes can result in simpler drive circuitry and reduced die area for manufacturing cost savings of up to 50% with significantly reduced write time. Compared to floating gate FTP memories, ReRAM scales well below 28nm, is more secure and is not affected by ultraviolet light, electromagnetic waves or moving subatomic particles. In addition, CrossBar's ReRAM has special security features such as block locking and memory zeroization for additional protection. Using CrossBar's ReRAM technology, not even transmission electron microscopy (TEM) techniques can reveal which ReRAM cells are programmed, dramatically reducing the chances of reverse engineering for highly secure applications.

Since MTP, FTP, OTP memories and PUF keys are able to share a monolithic ReRAM manufacturing process and control circuitry, a single chip design can now support custom chips by dynamically re-sizing memory during test time, offering CrossBar business partners additional flexibility.

Whether your embedded NVM implementations require PUF keys or KBytes to MBytes of high-performance MTP, FTP or OTP memories, CrossBar's ReRAM has the solution for you and your application.