Nonvolatile memories for IoT applications

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The Internet of Things (IoT) refers to the world where humans, machines and the environment communicate between themselves using various sensor enabled end user semiconductor devices called IoT motes. Large volume Flash NAND memories for Big Data storage and analyses are employed in IoT cloud platforms and fabricated in deeply scaled down technologies with an outlook for 3D integration. At the same time, the end user devices require specialized non-volatile memories (NVM) to support sensor calibration, user personalization, protection from hacking, code and data storage. IoT motes run on small batteries or use energy harvesting. Thus, ultra low power consumption is the main feature of NVM suitable for IoT motes. Other requirements include enhanced security and reliability and low fabrication costs.

In this presentation, we focus on the embedded memories for IoT motes, typically fabricated in 180nm to 65nm technology nodes together with sensors , RF blocks and power management circuits comprising the wireless sensor chips. Small volume (up to ~16 kbit) memory modules are currently of the greatest demand and have different endurance targets. It is expected that larger memory blocks (probably, up to ~1 Mbit) would be needed to support gathering information by intelligent sensors, advanced communication protocols and enhanced security in future IoT motes.

We review the advantages and limitations of memories advertised as IoT NVM by different IP vendors and then describe several original solutions developed in TowerJazz fabs. TowerJazz NVM can be divided into two groups: (i) single Poly, no mask adder low power consuming EEPROMs; (ii) integrated back-end memories (MRAM and ReRAM). As an example of the first group, original single Poly compact C-Flash memory module employing Fowler-Nordheim programming and erase and CMOS inverter read-out is presented . It includes NVM drivers with <50pW static power in readout. The memory was realized both on bulk CMOS and SOI platforms and allowed scaling down the memory cell area below 10um2, a record value for this class of NVM. We also report on integration of TAS and STT MRAM cells into the back end of CMOS process flows and discuss the trade-offs of different types of ReRAM for application in the end user devices. In the end of the presentation, we comment on the best NVM system for IoT and provide outlooks related to low power NVM technologies.