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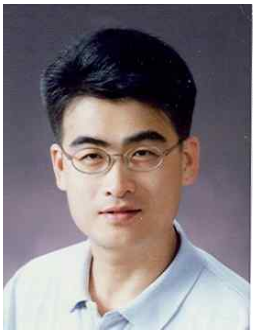	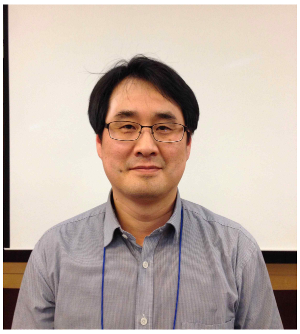		
Dr. Yoonjong Song	**Dr. Suock Chung**	**Dr. Hang-ting Lue**	**Dr. Junji Tominaga**
Challenges and prospectives of STT-MRAM and PRAM	RRAM potentials and challenges for high density application	Innovative 3D NAND Flash Devices for New Applications	Reconsideration of switching energy in PRAM, and proposal for entropy-controlled PRAM with topological insulating and spintronics functions

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Dr. Dr. Dominique Vuillaume	**Dr. Geoffrey W. Burr**	**Dr. Kay YAKUSHIJI**	**Dr. Dr. Hiroaki Yoda**
Organic Synapstor for Unconventional Computing and Biocompatible Applications.	Towards Storage Class Memory: Access devices for 3-D crosspoint using Mixed-Ionic-Electronic-Conduction (MIEC)	Development of novel materials for ultrahigh-density STT-MRAM application	STT-MRAM with Perpendicular MTJ, the progresses and prospects for further scalability

1. Title: Challenges and prospectives of STT-MRAM and PRAM

As major memory devices are approaching their theoretical limit, great interest and attention have been attracted on emerging new memories. Among them, spin-torque transfer magnetic RAM (STT-MRAM) and phase change RAM (PRAM) have been considered as one of strong candidates for next generation memory. As a frontier, PRAM was already implemented into mobile phones for field test, showing great feasibility of commercial memory products. However, in order to compete with current main memory, it needs to show practical scalability beyond 2xnm node as well as resolve the reliability issues such as thermal disturbance and retention. On the other hand, STT-MRAM are in the early development stage, but it possesses excellent intrinsic characteristics such as fast speed and strong endurance compared to PRAM. Therefore, in order to fully utilize the excellent properties for high density memory, it is highly required to resolve difficult obstacles such as side-short issue, process-induced degradation, and thus narrow sensing margin. In this paper, we discuss about challenges sprouting from products development and possible technical approaches to develop STT-MRAM and PRAM for high density memory application.

2. Title: RRAM potentials and challenges for high density application

As we have confronted with big data and cloud computing era, it would be expected to change not only computing system architecture, but also memory hierarchy. New computing system might request new memory which should be able to provide huge memory capacity with better performance than NAND, for instance, byte accessibility, shorter latency, lower power consumption, etc. RRAM has been considered as a one of good candidates for future memory and/or storage. In this talk, I'll share the RRAM potentials and key technical hurdles in this usage.

3. Title: Innovative 3D NAND Flash Devices for New Applications

3D NAND Flash already started mass production and it is expected to continue NAND Flash scaling beyond 1Tb density. In addition to the enormous desire of scaling and stackability, there are also other opportunities in providing new functions or applications by innovative device engineering. In this paper, we will discuss several device innovations that may be applied in various 3D NAND Flash architectures with unique advantages: (1) hot-electron programming method for reducing the programming voltage; (2) P-channel 3D NAND Flash devices for fast erasing; (3) Dual-channel (ambipolar) 3D NAND device for bit-alterable Flash. The physical principle, advantages and potential for new application, and device challenges are discussed.

4. Title: Reconsideration of switching energy in PRAM, and proposal for entropy-controlled PRAM with topological insulating and spintronics functions

Phase change memory (PCM) has been highly expected as a next generation non-volatile memory for FLASH. Samsung and Micron have already shipped the devices to the market. Behind the success, it has been criticized on the power consumption of PCM compared with the competitive other devices such as MRAM. The drawback basically depends on the switching mechanism solidifying the amorphous state through a molten phase, which requires more than 900 K. Although it has long been though that the amorphous-crystal phase change mechanism is essential to hold the large electrical resistance (> two orders of magnitudes), we discovered an alternative way to greatly suppress the power consumption using the second law of thermodynamics.

5.Title: Organic Synapstor for Unconventional Computing and Biocompatible Applications

We have recently demonstrated how we can use charge trapping/detrapping in an array of gold nanoparticules (NPs) at the SiO_2/pentacene interface to design a SYNAPSTOR (synapse transistor)

mimicking the dynamic plasticity of a biological synapse. This device (memristor-like) mimics short-term plasticity (STP) [1] and temporal correlation plasticity (STDP, spike-timing dependent plasticity) [2], two "functions" at the basis of learning processes. A compact model was developed [3], and we demonstrated an associative memory, which can be trained to present a pavlovian response [4].
Here we report on a detailed understanding of the dynamic electrical behavior of these synapstors, and how we can optimize them to work at low voltage (~ 1V) and to control their dynamic time-scale range. We also recently developed an electrolytegated version of this device for biocompatible applications [5]. We report on a detailed understanding of the electrical behavior of these synapstors in physiologically relevant conditions. We compare synapstors operated by the traditional bottom gate structure in air and by a water-electrolyte gate geometry. We discuss why these last results represent major improvements towards the use of these organic/NPs synapstor in biocompatible application e.g. as synapse prosthesis.

6.Title: Towards Storage Class Memory: Access devices for 3-D crosspoint using Mixed-Ionic-Electronic-Conduction (MIEC)

Memory technology is currently going through a period of rapid change, as new non-volatile memories (NVM) emerge that complement, augment, and potentially could even replace the traditional triad of SRAM, DRAM, and Flash. Storage Class Memory (SCM) is an emerging memory category that seeks to combine the benefits of solid-state memory, such as high performance and robustness, with the long-term retention and low cost of conventional hard-disk magnetic storage. Since such SCM technologies will require large nonvolatile memory arrays with very low cost per bit, 3D stacking of multiple layers of NVM crosspoint arrays in the Back-End-Of-the-Line (BEOL) layers is essential. In such an architecture, the NVM element at each crosspoint intersection must be in series with an access device, whose strong nonlinearity makes it possible to drive high current density through selected cells while maintaining ultra-low leakage through unselected cells.
This talk will provide a brief overview of the Storage Class Memory concept and a review of our work on novel access devices based on Cu-containing Mixed-Ionic-Electronic-Conduction (MIEC) materials. These access devices not only meet all of the above requirements but also support the bipolar memory operation critical for NVM candidates such as Resistance RAM (RRAM) and Spin-Torque-Transfer Magnetic RAM (STT-MRAM). Experimental results on prototype MIEC access devices will be shown, addressing topics such as cycling endurance, array fabrication and yield, co-integration with NVM candidates, speed, and scalability.

7. Title: Development of novel materials for ultrahigh-density STT-MRAM application

This talk describes a review and future prospects of tunnel magnetoresistance (TMR) effect and spin manipulation technologies such as spin-transfer torque (STT) for magnetic random access memory (MRAM). The emphasis of this talk is on the processes and related technologies for perpendicularly magnetized MgO-based magnetic tunnel junctions (p-MTJs). Our challenges for ultrahigh-density MRAM and novel related to MRAM are also discussed.

8. Title: STT-MRAM with Perpendicular MTJ, the progresses and prospects for further scalability

The biggest obstacle, large programming current which hindered denser MRAM development was solved by Perpendicular MTJ(P-MTJ). Large retention energy (⊿E) of $60k_BT$,goodwritingefficiency(⊿E/Ic) of 3 $k_BT/\mu A$,and Large MR of 200% were successfully demonstrated. As a result, P-MTJ opened a way to giga-bit density non-volatile random access memory. Fast switching at 2-3 ns. with small programming current of 50 μA was also demonstrated with P-MTJ. It enabled to reduce power consumption by 70% with so-called normally-off system. As a result, P-MTJ opened a way to fast non-volatile random access memory. Next target for MRAM may be over 10 giga-bit density. The prospect and the issues are going to be discussed based on data & estimations.