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Why We Need Spintronics in the Era of IoT and AI

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Development of spintronics non-volatile nanodevices and their integration with CMOS circuits has resulted in realizing low-energy, yet high performance integrated circuits for Internet-of-Things (IoT), and high performance computing and artificial intelligence. I start by pointing out that the usage of electric power by the IT sector will be significant in our future society along with the fact that for IoT it is essential to have low-power processing capability. I then show using several demonstrations that these challenges can be met by integration of non-volatile spintronics nanodevices with CMOS circuitry. Endurance and low supply-voltage operation make these spintronics device the only non-volatile alternative for the current volatile working memories such as DRAM and SRAM. The spintronics device commonly used is magnetic tunnel junction (MTJ), which can scale down to 20 nm with the perpendicular-easy-axis CoFeB-MgO system, is the device most widely employed for such a purpose. A brief review of the development of MTJs is given together with its ultimate scalability in the X nm (< 10 nm) dimension by showing MTJs with current induced switching and high thermal stability in the range of 4-8 nm. If time allows I will touch upon three-terminal spintronics devices that utilize spin-orbit torque arising from structures involving heavy metals as well as from antiferromagnets and show that it can mimic basic brain function opening a route toward neuromorphic applications.

Prof. Hideo Ohno received his Ph.D. from the University of Tokyo in 1982. He studied as a visiting graduate student at Cornell University in 1979 and joined Hokkaido University from 1982. He was a visiting scientist at the IBM T. J. Watson Research Center from 1988 to 1990. He was appointed Professor at Tohoku University in 1994 and is President of Tohoku University since 2018. His research interests include spintronics and semiconductor science and technology. He received the IBM Japan Science Award, the IUPAP Magnetism Prize, the Japan Academy Prize, the Tohoku University Presidential Prize for Research Excellence, the 2005 Agilent Technologies Europhysics Prize, the IEEE Magnetics Society Distinguished Lecturer for 2009, the Thomson Reuters Citation Laureate, the JSAP Outstanding Achievement Award, the IEEE David Sarnoff Award, the JSAP Compound Semiconductor Electronics Achievement Award, the Leo Esaki Prize, the C&C Prize, the MEXT Commendation for Science and Technology and the ISCS Welker Award. He has been an honorary professor of the Institute of Semiconductors, Chinese Academy of Sciences and a fellow of the Institute of Physics, the Japan Society of Applied Physics, the American Physical Society, and the Institute of Electrical and Electronics Engineers.

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