

Session 6: *Spintronics and Magneto Electronics*

by Sergio Valenzuela, Barcelona

Rapporteur: Christian Pithan, FZJ – PGI, Jülich

- **Comprehensive overview on spintronics related to**
 - 1.) Current technologies and developments (GMR, TMR, MRAM)
 - 2.) New fundamental physical phenomena and potentially emerging applications
(Transfer between pure scientific and application side is an important issue)
- **Charge transport vs. spin dynamics**

Spintronics opens possibilities for nonvolatile and low dissipation memory devices
(Spins do not need to be in motion for information transport)
- **Vision based on experimental and theoretical observations of the recent past**

Pure spin currents without charge transfer in integrated circuits and quantum manipulation / coupling of spin states.

 - At present: controlled by magnetic field or spin-polarized charge currents
 - Future: controlled by electric field and no charge currents
- **Giant Magnetoresistance (GMR), Tunnel Magnetoresistance (TMR)**
 - Parallel alignment → transmission, Antiparallel alignment → no transmission
 - Commercialization (Grünberg -patent): Magnetic sensors and data storage
- **Magnetic Access Random Memory (MRAM)**
 - At present: - **Toogle RAM** with low leakage, reduced dissipation, fast writing/ reading but larger power requirements for writing, cell size to large

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▪ **Magnetic Access Random Memory (MRAM)**

- Curr. development: - **Spin transfer torque RAM** (lithographically refined domains, reduced cell size)
- **Heat assisted switching RAM (TAS-MRAM)** (writing at elevated temperatures)
- **Other torque/switching mechanisms** (via electrical field, multiferroics ...)

▪ **Race track memory concept**

- Proposed by IBM
- Domain structure along a ferromagnetic line used to store information in a 3 dim. arrangement

▪ **Intriguing new physical discoveries from which practical possibilities could emerge:**

- RF-applications, spin logics, spin hall effect, spin Seebeck effect , Quantum computing ...
- Many encouraging proposals, developments or reports from the scientific literature
- Often still new fundamental physics and a lot of new scientific work needed
- Real application sometimes unclear (e.g. spin Seebeck effect)

▪ **Discussion with the discussant (Paolo Lugli) and the auditorium**

- Level of maturity and impact in society ...
- Role of contacts and interconnects in spin based devices ...
- Reliability and stability issues ...
- Role of the superparamagnetic limit in the evolution of MRAM and spintronic in general ...
- Role of molecular spintronics or molecular magnets (example of Ferritin molecule) ...