Annotated Bibliography

Deliverable 3

Annotated Bibliography Development

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References

1. Introduction and Background

Yakout, S. M. (2020). Spintronics: Future Technology for New Data Storage and Communication Devices. *Journal of Superconductivity and Novel Magnetism*, *33*(9), 2557–2580. https://doi.org/10.1007/s10948-020-05545-8

Hirohata, A., Yamada, K., Nakatani, Y., Prejbeanu, I.-L., Diény, B., Pirro, P., & Hillebrands, B. (2020). Review on spintronics: Principles and device applications. *Journal of Magnetism and Magnetic Materials*, *509*, 166711-. https://doi.org/10.1016/j.jmmm.2020.166711

The sources in this cluster will help us introduce our stakeholders into the world of Spintronics, as context for future sections, and get them thinking about specific issues that they could potentially fix with this technology. They are critical for understanding spintronics and their potential benefits within nanoelectronics, constituting an appropriately comprehensive and brief explanation on how spintronics work during the Introduction section of the symposium as well as setting up our Problem Statement. The first article states, "Spintronics is a promising technology which aims to solve the major problems existing in today's conventional electronic devices", sufficiently conveying its main idea; how it aims to elaborate upon Spintronics and explain why readers should care. The second article states, "Spintronics is one of the emerging fields for the next-generation nanoelectronic devices to reduce their power consumption and to increase their memory and processing capabilities. Such devices utilize the spin degree of freedom of electrons and/or holes, which can also interact with their orbital moments"; its advanced view on how spintronics work gives valuable insight on spintronics potential.

2. Current Trends and Developments

Barla, P., Joshi, V. K., & Bhat, S. (2021). Spintronic devices: a promising alternative to CMOS devices. *Journal of Computational Electronics*, *20*(2), 805–837. https://doi.org/10.1007/s10825-020-01648-6

El-Ghazaly, A., Gorchon, J., Wilson, R. B., Pattabi, A., & Bokor, J. (2020). Progress towards ultrafast spintronics applications. *Journal of Magnetism and Magnetic Materials*, *52*(C), 166478-. https://doi.org/10.1016/j.jmmm.2020.166478

The sources in this cluster will provide an understanding why spintronics is such a promising alternative for data manipulation and its current developments. We will use them as a viewpoint on the development of spintronics so far. The first article states, "Spintronic-based structures utilize electron's spin degree of freedom, which makes it unique with zero standby leakage, low power consumption, infinite endurance, a good read and write performance, nonvolatile nature, and easy 3D integration capability with the present-day electronic circuits based on CMOS technology"; showcasing advantages over the currently CMOS technology widely used. The second article states, "This review discusses our most recent advances in addressing these challenges and bridging together the two fields of spintronics and ultrafast magnetism to enable the integration of ultrafast spintronic devices."; this explains the utilization of another field to provide solutions and breakthroughs to problems that plagued spintronics.

3. Challenges and Limitations

Dieny, B., Prejbeanu, I.L., Garello, K. *et al.* Opportunities and challenges for spintronics in the microelectronics industry. *Nat Electron* 3, 446–459 (2020). https://doi.org/10.1038/s41928-020-0461-5

Kim, S. K., Beach, G. S. D., Lee, K.-J., Ono, T., Rasing, T., & Yang, H. (2022). Ferrimagnetic spintronics. *Nature Materials*, *21*(1), 24–34. https://doi.org/10.1038/s41563-021-01139-4

Liu, Y., Zeng, C., Zhong, J., Ding, J., Wang, Z. M., & Liu, Z. (2020). Spintronics in Two-Dimensional Materials. *Nano-Micro Letters*, *12*(1), 93–93. https://doi.org/10.1007/s40820-020-00424-2

This cluster touches on the Benefits and Impacts, Risks and Mitigation Strategies, and Implementation Plan components of the symposium, by highlighting the various constraints involved in practical Spintronics usage as well as proposing potential solutions for these and how they when carefully integrated could revolutionize industries.

4. Future Directions and Potential

Ameer, M. A., Mustafa, G. M., Gassoumi, A., Saba, S., Noor, N. A., Mumtaz, S., & Saad H.-E., M. M. (2024). Theoretical analysis of magnetic, optoelectronic, and thermoelectric properties of Cs2CuCrX6 (X = Cl and Br) double perovskites for spintronic and data storage devices. *The Journal of Physics and Chemistry of Solids*, *193*, 112149-. https://doi.org/10.1016/j.jpcs.2024.112149

Puebla, J., Kim, J., Kondou, K., & Otani, Y. (2020). Spintronic devices for energy-efficient data storage and energy harvesting. *Communications Materials*, *1*(1), 1–9. https://doi.org/10.1038/s43246-020-0022-5

Sanghal, T., Sabharwal, B., & Delaney, A. (2023). Superconductors and Spintronics: The Future of Hyper-Efficient Data Storage and Transport (Professor James Analytis). *Berkeley Scientific*, *27*(2). https://doi.org/10.5070/BS327262055

The sources in this cluster will support the “Benefits and Impacts” and “Implementation Plan” sections of our poster by exploring the promising future directions of spintronic technology. Together, they illustrate the anticipated societal impacts and efficiency gains, laying out a timeline for development and addressing challenges in energy use and environmental sustainability. By examining advancements such as energy-efficient data storage and innovative material applications, the sources provide a foundation for our claims on cost savings, efficiency improvements, and the broader societal benefits of spintronics.

5. Case Studies and Real-World Applications

Breakthrough for efficient and high-speed spintronic devices. (2022). In *Canada NewsWire*. PR Newswire Association LLC. https://inrs.ca/en/news/breakthrough-for-efficient-and-high-speed-spintronic-devices/

Hedin, E. R., & Joe, Y. S. (2014). *Spintronics in Nanoscale Devices* (1st ed.). Pan Stanford. https://doi.org/10.1201/b15353

The case studies and real-world applications cluster will support the “Implementation Plan” section of our poster. The cluster and sources directly apply to this section of the poster highlighting the developments that have currently been made in the world of spintronic technology. These sources provide insight into the practical developments being made in spintronics, including the creation of high-speed, energy-efficient devices and the use of advanced tools like x-ray microscopes to observe spin dynamics. The breakthroughs currently being made helps provide a timeline for implementation and mass consumer adoption of spintronic technology, such as in nanoscale devices.

6. Ethical and Social Implications

Palomino, A. Marty, J. Auffret, S. Joumard, I. Sousa, R.C. Prejbeanu, I.L. Ageron, B. Dieny, B. (2021). Evaluating critical metals contained

in spintronic memory with a particular focus on Pt substitution for improved sustainability. *Sustainable Materials and Technologies.* Volume 28. https://doi.org/10.1016/j.susmat.2021.e00270

Ghosh, S. (2016). Spintronics and security: Prospects, vulnerabilities, attack models, and preventions. Proceedings of the IEEE, 104(10), 1864-1893. https://doi.org/10.1109/JPROC.2016.2583419

The sources in this cluster will support the “Benefits and Impacts” as well as the “Risks and Mitigations” sections of our poster. They focus on the ethical and social impacts of spintronics technology, focusing on environmental concerns, data security risks, and potential solutions. These sources also suggest alternatives (mitigations), such as using sustainable materials and implementing preventative measures to minimize data security vulnerabilities.