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Interfaces in Spintronics

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The term "*spintronics*" was coined in 1996 by S. A. Wolf during an informal meeting at the Defense Advanced Research Projects Agency (DARPA), while trying to name a research program focused in developing spin transport-based electronic devices.[1] As a matter of fact, the appearance of spin-based devices is dated several years earlier, with the first spin transport experiments most likely being reported by R. Meservey and P. M. Tedrow in the early 70s. In this work, the spin polarization of 3d ferromagnets was measured by tunneling into superconductors.[2,3] Without doubt, the most impactful research in spintronics (even if the name was still not coined at that time) is connected to the late 80s research on giant magnetoresistance (GMR), as independently conducted by the groups of A. Fert[4] and P. Grünberg,[5] who were awarded the Nobel prize in Physics in 2007.[6] Their research laid the foundations for a revolution in data storage, by providing routes to boost the storage capacity of hard drives by several orders of magnitudes, from <1 Gbit/in^2 to ~600 Gbit/in^2,[7] also thanks to the development carried out at IBM by the group of S. S. P. Parkin.[8]

There is practically no spintronic device in which the *interfaces* between materials with different chemical, structural, or magnetic properties do not play a crucial role in driving functionalities, as illustrated by the following examples. (i) The performance of a magnetic tunnel junction is strongly dependent on the quality of the tunneling process between ferromagnetic layers, a process largely determined by its interfaces' properties. (ii) Spin-charge interconversion phenomena and the resulting spin accumulation in heterostructures composed by magnetic materials and heavy metals (or topological matter) are to a large extent interfacial processes. (iii) Interfacial Dzyaloshinskii-Moryia interaction drives the creation and manipulation of skyrmions in ultrathin magnetic layers. (iv) Systems based on the interface between superconductors and topological insulators are considered to be possible routes to observe the elusive Majorana fermions.

The spintronics arena is flourishing more than ever. While devices based on magnetoresistive phenomena have been in production for several years now, a plethora of new materials and concepts just entered the game, offering the potential to make a significant leap forward.

This special issue of "Interfaces in Spintronics" in *Advanced Materials Interfaces* is a collection of reviews, perspectives, and original research papers, which focus on the intimate connection between interfaces' properties and their target application in spintronic devices. The content ranges from the development of novel materials (two-dimensional ferromagnets, topological insulators, Weyl semimetals, Heusler alloys and emerging ferri- and antiferromagnetic compounds) to their inclusion in mature spintronic devices such as magnetic tunnel junctions. A number of papers also address the manipulation of magnetic properties of materials through molecules, magneto-ionic or magneto-electric effects, and by excitation with light. The comprehensive characterization of interfaces with a wide range of analytical tools (such as spin-orbit torque, terahertz spectroscopy, ferromagnetic resonance and Mössbauer spectroscopy) is also the subject of several contributions. Thanks to a strong interdisciplinarity of the collected manuscripts, this special issue could serve as a basis to establish fruitful connections among research groups from all over the world.

More than ever, interfaces will keep playing a key role in driving the functionalities of future spintronic devices, to the point in which the interface will be the device. Sharing complementary expertise will be fundamental to address present and future open questions in the field.

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Roberto Mantovan obtained his PhD in physics in 2006. Since 2009 he is a Research Scientist at CNR-IMM, Unit of Agrate Brianza (Italy), being involved in several national and international projects within different topics in spintronics. His main research activities currently concern spintronics with topological matter, the atomic-scale structural/chemical/magnetic characterization of bulk materials, thin films, and interfaces by means of Mössbauer spectroscopy, magnetotransport, and thin films growth mainly by chemical methods. Since 2008, within the H2020 Skytop project, he coordinates the development of chemical methods to synthesize large-area topological materials, their functional characterization, and their integration with magnetic layers toward new spintronic applications.

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