At the interface between nitride compounds and quantum materials

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Semiconductor nitride compounds own their relevance, not only to state-of-the-art applications in opto- and high-power-electronics, but also to a number of features particularly attractive for spintronics and spin-orbitronics, enabling, e.g., spin-charge interconversion via spin-orbit coupling associated with inversion asymmetry and leading to a sizable Rashba field and piezoelectric properties. Through the addition of magnetic dopants fostering the formation of magnetic complexes or driving the system to the state of a condensed magnetic semiconductor, these materials open wide perspectives in both fundamental and application-oriented research.

An overview is provided here on how, by controlling the fabrication parameters and establishing a comprehensive protocol of characterization involving also synchrotron-radiation-based methods, we have unraveled and can now control a number of relevant features of these systems. Particularly significant in this context is the generation of pure spin current at room temperature in nitride-based bilayers, pointing at these systems as efficient spin current generators. Besides controlling the self-aggregation and performance of embedded functional magnetic nanocrystals and of optically active complexes, we have proved that the magnetization of dilute III-nitrides doped with transition metals may be controlled electrically. In this way, the piezoelectricity of wurtzite semiconductors and electrical magnetization switching have been bridged. Prospects for proximity-induced topological superconductivity in heterostructures combining graded and Rashba III-nitrides with layered s-wave superconductors are also discussed.

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