First-principles theory of defect-based qubits in heterogeneous semiconductors

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Recently, significant progress has been made toward full control of the quantum states of spins and charges in a variety of semiconductors and solid-state nanostructures for applications in quantum information processing, quantum optics, and quantum sensing. Such platforms include the NV center in diamond, dopants in silicon, single-photon emitters in 2-dimensional crystals, and solid-state quantum dots. Being in the solid-state, the listed platforms also have a significant potential for scalability. In the first part of the talk, we will outline the principles underlying the listed quantum defect systems in terms of its manipulation and operation schemes. In the second part of the talk, we will highlight some of our own research efforts [1-6] devoted to the point-defect-based qubits in heterogeneous semiconductors. First, we will discuss the Janus aspects of nuclear spin baths: the bad being the source of decoherence for electron spin qubits and the good being useful resources for quantum memory applications. We will show that it is possible to reconcile these conflicting aspects of nuclear spin baths by developing spin qubits either in heterogeneous crystals or low-dimensional crystals. Second, we will discuss computational defect designs to search for promising defect candidates in a variety of heterogeneous semiconductors toward scalable and coherent hybrid quantum systems.

[1] G. Noh, D. Choi, J. Kim, D. Im, Y. Kim, H. Seo, and J. Lee, Nano Lett. **18**, 4710 (2018).

[2] M. Ye, H. Seo, and G. Galli, *submitted* (2018).

[3] H. Seo, H. Ma, M. Govoni, and G. Galli, Phys. Rev. Mater. **1**, 075002 (2017).

[4] H. Seo, A. L. Falk, P. V. Klimov, K. C. Miao, G. Galli, and D. D. Awschalom, Nat. Comm. **7**, 12935 (2016).

[5] H. Seo, M. Govoni, and G. Galli, Sci. Rep. **6**, 20803 (2016).

[6] W. F. Koehl, H. Seo, G. Galli and D. D. Awschalom, MRS Bull. **40**, 1146 (2015).