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Ultrafast Quantum Control and Quantum Processing in the Vibronic States of Molecules and Solids[1] BENJAMIN SUSSMAN, PHILIP BUSTARD, DUNCAN ENGLAND, RUNE LAUSTEN, Natl Research Council-Canada — The unusual features of quantum mechanics are enabling the development of technologies not possible with classical physics, including applications in secure communications, quantum processing, and enhanced measurement. Efforts to build these devices utilize nonclassical states in numerous quantum systems, including cavity quantum electrodynamics, trap ions, nuclear spins, *etc.* as the basis for many prototypes. Here we investigate vibronic states in both molecules and bulk solids as distinct alternatives. We demonstrate a memory for light based on storing photons in the vibrations of hydrogen molecules and the optical phonons of diamond. Both classical [1,2] and nonclassical [3] photon states are used. These THz-bandwidth memories can be used to store femtosecond pulses for many operational time bins before the states decohere, making them viable for local photonic processing. We investigate decoherence and major sources of competing noise. While sustaining quantum coherence is critical for most quantum processing, rapid dephasing can also be used as a resource in these systems for rapid quantum random number generation, suitable for high-performance cryptography [4,5]. [1] Bustard, P. J., *et al.* Phys. Rev. Lett., 111(8). (2013). [2] England, D. G., *et al.* Phys. Rev. Lett., 111(24). (2013) [3] *In preparation* [4] Bustard, P. J., *et al.* Opt. Express, 21(24), 29350-29357. (2011). [5] England, D. G., *et al.* Appl. Phys. Lett. *Accepted.* (2014)

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