algorithm, a well-known example of a deterministic quantum algorithm which is exponentially faster than its classical analogue.

However, an E-driven phase gate is usable only if a large number of operations can be made before the coherence is lost. Efficient operation requires strong spin-electric coupling but the same mechanisms that originate the coupling (spin-orbit interaction and atomic displacements) are also responsible for magnetic relaxation and loss of coherence. The Ce$^{3+}$ in YAG has good coherence lifetime, 15 $\mu$s at 10 K, thanks to its rigid lattice and low nuclear spin concentration. Interestingly, a contemporaneous investigation by Liu J et al. highlighted even stronger spin-electric coupling in a holmium(III) polyoxometalate [5]. The strength of the effect has been rationalized considering the coupling with a vibration mode of the Ho coordination sphere. Shorter coherence lifetimes were observed, although these were enhanced when protected at clock transitions.

In conclusion, recent advances in E-field coherent control of spin qubits suggest that single spin qubit operation is viable and particularly promising for discrete molecular systems. However, optimization of coherence time and spin-electric coupling poses antithetic conditions and remains an open challenge for chemists and physicists working in this fascinating field.

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**MATERIALS SCIENCE**

A promising route to neuromorphic vision

Leon Chua

The human vision system has a very strong capability in perceiving surroundings. Such visual perception starts in the retina, which receives and preprocesses the visual input in the form of light, and ends up with high-level processing in the visual cortex of the brain (Fig. 1a). As such, we can understand what the visual inputs represent while consuming little energy. It has been a long-sought dream for human beings to build a powerful and energy-efficient intelligent vision system that has a superior ability, similar to the human brain. Computer vision, as a similar model to the human brain, aims at viewing, processing and understanding images in the same way as human beings, and has become one major technological advancement in building intelligent machines [1]. However, the mainstream technology for computer vision is based on algorithms running on a von Neumann architecture computer, and cannot emulate the hierarchal organizations and biological functions of the human vision system. In particular, traditional computer vision in conjunction with the conventional charge-coupled device (CCD) and complementary metal-oxide-semiconductor (CMOS) image sensors suffers from challenges in latency and power consumption as a high volume of redundant visual information is sensed and then has to be processed.

A recent work [2] on the development of the neuromorphic visual system attempted to replicate the human’s capability of visual perception and represents a significant advancement towards the

**Figure 1.** Human vision system (a) and neuromorphic vision system (b) composed of crossbar array and van der Waals heterostructure materials.
creation of intelligent machines. This interesting work led by Shi-Jun Liang and Feng Miao at Nanjing University reports development of a brain-inspired visual perception system by networking a retinomorphic sensor and a memristive crossbar, in an effort to overcome the challenges faced with conventional computer vision. Using van der Waals heterostructure and a memristive crossbar to emulate the retina and visual cortex of the human vision system, respectively, as schematically shown in Fig. 1b, Liang and Miao et al. for the first time built a neuromorphic vision system with hierarchical organizations and biological functions similar to that of the human brain. The retinomorphic sensor based on van der Waals heterostructure not only mimics the hierarchical structure of the human retina but also replicates its biological functionalities in image sensing and early processing. By networking with a large-scale memristive crossbar, they demonstrated that the early processing occurring in the retinomorphic sensor allows for drastically improving pattern recognition, which can be modelled by cellular neural networks [3,4]. Furthermore, they showed that the proposed architecture also holds great promise in carrying out object tracking tasks.

The work led by Liang and Miao is a major breakthrough in prototype demonstration of a neuromorphic vision system that allows for image sensing and processing as well as perception in the full analog domain. This encouraging work opens up a promising route to be followed in the future for exploring its applications in driverless cars, smart surveillance, intelligent healthcare, etc. We can envisage that this work could stimulate further explorations of more advanced intelligent systems by highly mimicking human beings.

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