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The Role of Physics in New Information Processing Technologies

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As semiconductor technology moves ever closer to the ultimate physical limits for scaling of devices that utilize electrons as information bearing particles, many new opportunities for research in the physical sciences are emerging. In order to achieve the limits for electron transport scaling, many new materials and processing problems must be overcome including the invention of both low and high dielectric-constant material technologies and new ideas for interdevice communication. If we look beyond the limits of scaling electron devices, many more challenging research opportunities exist in the areas of physics of information carriers and physics of communication. On the physics of information carriers, it may be that for devices with critical dimensions less than one nanometer, an information bearing particle much more massive than the electron would be desirable. As another example, we have observed that for spin-based systems, high magnetic fields are needed for reliable spin manipulation. Breakthroughs in the physics of spin manipulation are needed. For example is it possible to obtain suitable materials that exhibit a high g-factor to enable controllable devices that operate with reasonable energies and magnetic fields. The option operation in a non-equilibrium thermal environment also needs to be considered. On the physics of communication, for branched communication between nanodevices, it may be that we need to supplant metallic or nanotube interconnects with systems that utilize the wave nature of quantum particles to minimize energy dissipation.