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Silicon Nanowire Devices

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Metal-catalyzed, self-assembled, one-dimensional semiconductor nanowires are being considered as possible device elements to augment and supplant conventional electronics and to extend the use of CMOS beyond the physical and economic limits of conventional technology. Such nanowires can create nanostructures without the complexity and cost of extremely fine scale lithography. The well-known and controllable properties of silicon make silicon nanowires especially attractive. Easy integration with conventional electronics will aid their acceptance and incorporation. For example, connections can be formed to both ends of a nanowire by growing it laterally from a vertical surface formed by etching the top silicon layer of a silicon-on-insulator structure into isolated electrodes. Field-effect structures are one class of devices that can be readily built in silicon nanowires. Because the ratio of surface to volume in a thin nanowire is high, conduction through the nanowire is very sensitive to surface conditions, making it effective as the channel of a field-effect transistor or as the transducing element of a gas or chemical sensor. As the nanowire diameter decreases, a greater fraction of the mobile charge can be modulated by a given external charge, increasing the sensitivity. Having the gate of a nanowire transistor completely surround the nanowire also enhances the sensitivity. For a field-effect sensor to be effective, the charge must be physically close to the nanowire so that the majority of the compensating charge is induced in the nanowire and so that ions in solution do not screen the charge. Because only induced charge is being sensed, a coating that selectively binds the target species should be added to the nanowire surface to distinguish between different species in the analyte. The nanowire work at Hewlett-Packard Laboratories was supported in part by the Defense Advanced Research Projects Agency.