Radial Addressing of Nanowires

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Recent research on molecular-scale wires and switches has established the possibility of assembling without lithography very high density crossbars composed of wires with nanometer-sized diameters. These crossbars consist of two orthogonal sets of parallel nanowires (NWs) separated by a switcheable molecular layer. They can be used as memories or programmed logic arrays.

To read and store data in nanoarrays requires that individual NWs be addressable. That is, it must be possible to select one NW from each orthogonal set NWs and apply a voltage to it or pass a current through it. To control NWs from the lithographic level requires that mesoscale wires (MWs) be used to address NWs. If each NW is connected to a single MW, the close packing possible with NWs is lost. Thus, schemes are needed that use multiple MWs to control individual NWs. Several such schemes have been proposed. All assume that MWs are placed at right angles to NWs.

The first scheme, the **randomized decoder**, assumes that gold particles are placed at random between undifferentiated NWs and MWs [1]. When the NWs are lightly doped, the MWs with random connections act as field effect transistors (FETs) to provide NWs with addresses. The second scheme, the **mask-based decoder**, assumes that high-K dielectric regions are placed between MWs and undifferentiated lightly-doped NWs [2, 3]. Some NWs are shielded from each MW and others are not, thereby providing NW addresses. Undifferentiated NWs with small diameter and pitch can be placed in parallel in one step through nano-imprinting[4, 5], stamping [6] or nanolithography [7]. The third scheme, the **encoded-NW decoder** assumes that NWs are differentiated during their manufacture by growing lightly doped regions into NWs (modulation doping) that have a length equal to the width of MWs [8, 9]. The doping patterns provide a means to turn on NWs selectively. It is proposed that these NWs be assembled fluidically into parallel orthogonal arrays [10, 11].

In this paper, we introduce **radial coding**, a new way of encoding core-shell NWs [12] by growing etcheable shells of different types on them. This new NW encoding method has several advantages: a) correct operation is more certain than with the randomized decoder; b) it requires fewer MWs to control NWs than the mask-based decoder; and c) registration with MWs of doped NW regions is guaranteed by construction, unlike the encoded-NW decoder. The new core-shell encoding scheme has the disadvantage that it can increase the pitch of NWs because shells add to NW diameters. However, by making good architectural choices and using clever methods to assign external addresses to internal NW addresses, this

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encoding method is competitive in NW pitch with other proposed NW encoding schemes while enjoying the advantages mentioned above. We present efficient methods to decode radially coded NWs and to realize them with a nearly minimal number of etching steps.

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