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Negative Differential Resistance Phenomena in Molecular Metal-Insulator-Metal Junctions[1]

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Negative-differential-resistance (NDR) phenomena have been observed in metal-insulator-metal (MIM) junctions composed of various materials and are of interest because of their potential for producing bistability, oscillation, and gain in electronic circuitry. Recently, NDR has been observed by a number of different techniques in molecular MIM junctions based on self-assembled monolayers of nitro-substituted oligo(phenlyene-ethynylene) (OPE). Like NDR in other MIM systems, the mechanism behind the NDR in molecular MIM junctions is not well understood. We have recently investigated Hg-C14//OPE-Au bilayer molecular junctions that exhibit stable NDR characteristics over many bias sweeps, thereby permitting a systematic study of this effect. Our results on the variation of NDR peak with sweep rate, the charge flow during the NDR branch, the current-voltage characteristic for cyclic sweeps and other details of the characteristics suggest that the NDR is caused by charge storage (oxidation or reduction) within the junction that acts to modify the effective tunneling parameters. Quantitative estimates of the stored charge, the tunneling barrier height and effective mass also support this basic physical picture. These results will be compared with those for other MIM junction systems and discussed in the context of proposed mechanisms for this system. The physical picture developed here should be useful for understanding molecular MIM junctions at a fundamental chemical level.

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