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PERCOLATION PHENOMENA IN NETWORKS OF SILICON NANOCRYSTALS AND CARBON NANOTUBES

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Abstract. *We discuss percolation phenomena in two nanostructures with percolative properties, one being formed by Si nanocrystals embedded in amorphous SiO_2 matrix and the second by a network of multi-walled C nanotubes embedded in amorphous Si_3N_4. This paper focuses on voltage percolation thresholds evidenced in current-voltage characteristics taken on both nanostructures. The shape of voltage percolation thresholds is common for both nanostructures and consists in a saturation plateau region of the current, followed by an abrupt increase.*

Key words: g percolation, electrical transport, silicon nanocrystals, carbon nanotubes

1. Introduction

The physical properties of nanostructures related to percolation phenomena are intensively investigated in the last decade. The main investigated are the nanostructures based on Si, Ge and C nanotubes (CNT), both single-walled (SWCNT) and multi-walled (MWCNT). Among the three basic percolation theories, the site percolation model describes well different characteristics, particularly the electrical ones [1]. The transport characteristics in electronic devices are also depicted by means of the bond percolation theory. If one considers a box with an infinite linear size, filled with both metallic balls with resistance R and plastic balls with infinite resistance, all of them having identical diameters, then the linear dimension (χ) of the largest clusters formed by interconnected metal balls is given by the formula $\chi \propto \chi_0 |x - x_c|^{-\nu}$. By χ_0 we noted the size of the ball, which generally represents a fundamental scale factor, by x and x_c the fraction and the critical fraction of metallic balls respectively, and ν = 0.88 is the universal critical index of the correlation radius for three dimensional systems [1, 2]. The numerical value of the critical fraction x_c depends on the balls arrangement, i.e. x_c has different values for a random or an ordered distribution. Also, x_c takes different numerical values for site percolation and bond percolation, respectively [1, 3].

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