Transmission Line Model and Performance Analysis of Carbon Nanotube Interconnects

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In the future microelectronics technology, carbon nanotubes (CNTs) are considered as a very promising candidate in the design of high-density interconnects for their unique properties. Among different CNTs, metallic single-walled carbon nanotubes (SWCNTs) should be mentioned, because of their high current carrying capacity and possibility to achieve ballistic transport.

If we use a SWCNT to design an interconnection, its circuit model must be known firstly. To the best of our knowledge, based on the theory of equivalent transmission line, the RF circuit model of a CNT has been first proposed by Burke more recently (P. J. Burke, *IEEE Trans. Nanotechnology*, 1(3), 139-144, 2004), in which distributed kinetic and magnetic inductances, distributed quantum and electrostatic capacitances are introduced. In the Burke's model, the conductive property of a CNT is only treated as ballistic transport. Further, Raychowdhury *et al* have taken scattering effect into account, and they have proposed a RLC model for the performance analysis of a CNT (*4th IEEE Conf. Nanotechnology*, 608–610, 2004). However, in this RLC model, the contact resistance of the metal nanotube is not taken into account and this is inaccurate.

In this work, we proposed an equivalent distributed transmission line RLC model for metallic SWCNTs, by considering the effect of imperfect metal-nanotube contact R_{mc}. This modified model is shown in Fig. 1 below, where $R_{FC} = h^2/4e^2$, $R_{SCAT} = h^2/4e^2\left(1/\lambda - 1/l\right)$, $L_{CNT} = h/2e^2 v_F$, $C_Q = 2e^2/hv_F$, and the value of C_E should be different for single, parallel and bundle CNTs cases, respectively. Using our proposed model, further theoretical investigations of some CNT interconnects have been carried out, and their performances are compared with certain copper interconnects.

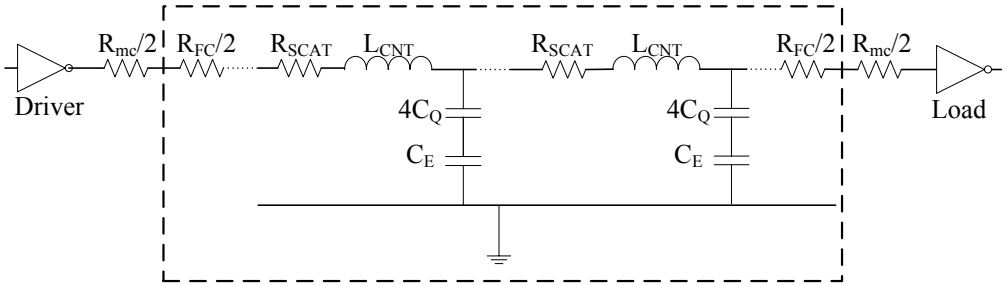

Figure 1. An equivalent distributed RLC model for a SWCNT, where the imperfect metal-nanotube contact is considered.