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Carbon nanotubes for interconnects in integrated circuits

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Carbon nanotubes are one of the materials that may be used for advanced interconnects beyond the 16nm node thanks to there extreme resistance to electro migration and to bottom up approach which allow to grow them in tiny holes with very high aspect ratio. The resistance of a via with area A and height h filled with CNT is expressed by $R_{via} = \frac{rq+rsh+rc}{Ad_t}$ where rq, rs, rc are respectively the 6.5kΩ quantum resistance, the scattering resistance and the contact resistances of one tube. To be competitive with copper via resistance, a large density d_t of carbon walls have to be paralleled. Following ITRS needs a density of 2 or 3 10^{13}cm^{-2} conducting CNT walls have to be obtained. This optimum wall density requests the growth of highly packed few nanometre diameter CNTs. Such density has been the main bottleneck for the development of CNT interconnects. Recently ultra high density integration scheme have been demonstrated and for the first time wall density close to the requested one have been integrated in devices. Such density comes from the development on conductive substrates of a CNT growth mode normally used to obtain forests of small tube diameter on insulating substrate like alumina. With this mode, CNTs are grown with base growth mode which is the mode requested for SWCNT or DWCNT thus by continuity it will be possible to increase the density still further by increasing the density of catalyst particles. Our bottom metal of choice is AlCu with iron as catalyst. With this system tube contact resistance between 10^4 to 10^6 Ohm have been measured on blanket AlCu substrates. This resistance must be decreased by one or two order of magnitude while increasing further CNT density. In this paper we will present our last integration developments and the role of plasma pre-treatment of the iron aluminium interface in order to decrease the contact resistance. We will show that the bottom profile of via has a major impact on the quality of CNT growing in the holes and discuss future evolutions of this technology.