An updated review of nanotechnologies for the space elevator tether

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The space elevator tether requires an extraordinary specific ultimate strength σ_ρ (ratio between ultimate strength σ and density ρ) and carbon nanotubes (CNTs) have been identified as the ideal candidate because of their astonishing strength[1,2] (σ_ρ>60MYuri for CNT manufactured by CVD with radii in the region of r~50nm, fig. 1). Yet, the highest values of σ_ρ were measured on samples only few microns long[1,2] and long tethers are as strong as the weakest link. Indeed, the fabrication of flawless wires has been proved very challenging. Since 2007 reports of CNTs longer than 15mm have become common (a single CNT as long as 300 mm was allegedly made at the MIT Institute for Soldier Nanotechnologies in 2009) and CNT bundles longer than 18mm have also been achieved; unfortunately their σ_ρ has not been reported, yet.

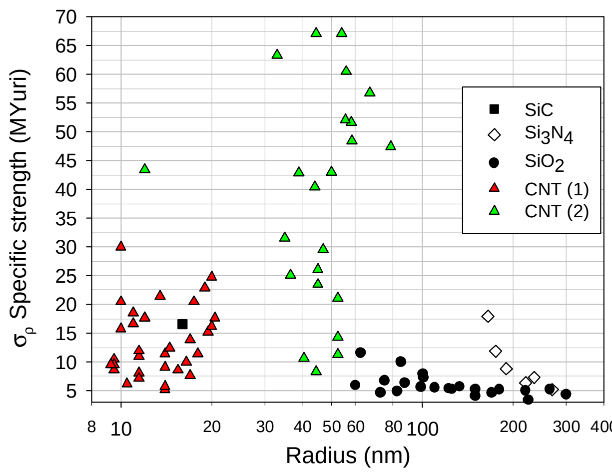

Fig. 1. Specific ultimate strength σ_ρ as a function of size for carbon nanotubes[1,2] (CNTs) and for silicon carbide[3] (SiC), silicon nitride[4] (Si_3N_4) and silica[5] (SiO_2) nanowires. CNTs have been fabricated by arc-discharge (group 1)[1] and by chemical vapour deposition (CVD) (group 2)[2].

An alternative path to manufacture km-long tethers with σ_ρ>20MYuri could rely on the possibility to join different CNTs[3] with joints as strong as the CNT themselves[4], if parallel processing can be employed.

Finally, combinations with other high-σ_ρ nanowires can be envisaged: in the last few years, four types of nanowires with σ_ρ>5MYuri have been reported in the literature; fig. 1 summarizes the data on silicon carbide[5] (SiC), silicon nitride[6] (Si_3N_4), and silica[7] (SiO_2). SiC and Si_3N_4 at their best can provide σ_ρ>16 MYuri, while the greatest value reported for silica glass is smaller, σ_ρ~12MYuri. The great benefit of these nanowires relies in their possibility to be manufactured in extremely long lengths with minor changes to the current fabrication technology: silica glass allows for the prompt manufacture of km-long wires. Si_3N_4 can also be manufactured in relatively long lengths with the current technology, but the length of defect free Si_3N_4 single crystals has never been tested.

Reference

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