

# Comment on “Advanced Mechanical Properties of Graphene Paper” by Ali R. Ranjbartoreh et al. Vol. 109, 2011

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The paper “Advanced Mechanical Properties of Graphene Paper” by Ali R. Ranjbartoreh et al. published in Journal of Applied Physics Vol. 109, 2011 presents the following conclusions: “GP and G-ODA have been fabricated by directional flow-induced assembly of graphene nanosheets. FE-SEM observation revealed that the structure of GP is similar to the interlocked tiles. In general, GPs have higher Young’s modulus and strength while G-ODA samples exhibit higher stiffness. Heat treated GP shows very high hardness (~217 kg f /mm<sup>2</sup>) which is almost two times that of carbon steel, moreover its yielding strength (~6.4 TPa) is several times higher than that of carbon steel. GPs demonstrate outstanding bending rigidity and elastic modulus under bending which is about thirteen times that of carbon steel. These superior mechanical properties should render GP an excellent material for engineering applications.” (pp. 014306-5-6)

The main finding is that heat treated GP shows very high hardness of ~217 kg f /mm<sup>2</sup> and yielding strength ~6.4 TPa. From the data shown in TABLE II (p. 014306-5) it is seen the yielding strength is **6399.72 MPa**, which is **~6.4 GPa**, not **~6.4 TPa**.

The authors present in the paper: “By means of hardness, yielding strength of materials can be estimated as

$$\sigma_y = CH_v \quad (9)$$

where  $C$  is a constant determined by geometrical factors, usually ranging between 2 and 4.” (pp. 014306-4-5)

It is seen from TABLE II (p. 014306-5) in the paper that yielding strength was calculated from Vickers hardness by

$$\sigma_y = 3H_v$$

i.e. for Heat treated GP,  $\sigma_y = 3 \times 217.53 \times 9.81 \approx 6399.72$  (MPa).

Three points should be noted that when using Eqn. 9: (1) This is only valid for soft metals and for steel, the relation  $\sigma_u = 3H_v$  exists, where  $\sigma_y$  is ultimate strength, not yielding strength; (2) The units of  $\sigma_y$  and  $H_v$  are MPa and kgf, respectively. Thus, the  $H_v$  should not be converted to MPa; (3) As for all empirical relationships, the data should only be used for materials that were within the scope of the original studies and extrapolations beyond the limits of the presented data are not recommended.

If SI units are used for both  $\sigma_y$  and  $H_v$ , Eqn. 9 should read

$$\sigma_y \approx \frac{H_v}{3}$$

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Thus, for Heat treated GP,  $\sigma_y = \frac{217.53 \times 9.81}{3} \approx 711.32$  (MPa). Same for the other data listed in TABLE II.

This clearly shows that the data presented in the original paper are faulty and the conclusion that the yielding strength of graphene paper is significantly higher than that of steel is invalid.