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Control over the wettability of vertically-aligned multi-wall carbon nanotubes films in a large range from hydrophilicity to super-hydrophobicity.

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Abstract – Modification of vertically-aligned multi-walled carbon nanotubes (VACNT) films were carried out with oxygen pulsed DC plasma and CO_2 laser treatments to control of superficial polarity. The effect of each treatment on wettability of VACNT films were evaluated in terms of dispersive and polar energy contributions. Measurements of the contact angle (CA) between liquids with different polarities (glycol, glycerol, and water) and modified VACNTs surfaces were carried out by the sessile drop method. The oxygen plasma conferred hydrophilicity to VACNT surfaces, whilst the CO_2 laser superhydrofobicity, when water was used.

Many applications involve manipulation of liquids on (or across) surfaces [1], as in microfluidic devices [2]. For these applications, the main property to be investigated is the wettability, which involves both topography [3] and physical chemistry [4] phenomena. For this reason, vertically-aligned multi-walled carbon nanotubes (VACNT) are a promising material for microfluidic applications [4], since their superhydrophobicity can be controlled by incorporation of functional groups [4] or building arrays with different geometries [5]. In this work, we have proposed a method to obtain control on wettability of VACNT surfaces, using oxygen DC pulsed plasma and CO_2 laser irradiation. The VACNTs were produced as a film, using a microwave plasma chamber (2,45GHz) on titanium substrates (1.0x1.0cm2) covered by a thin Ni catalyst layer. Superhydrophilic surfaces were obtained by the oxygen pulsed DC plasma treatment (80 mtorr, 1sccm, 700V, 2min) to incorporate polar groups (-C=O, -COOH) on VACNT tips [6].
CO_2 laser (Synrad Model J48), was used to irradiate the functionalized VACNT at different power levels (maximum real power - MP). The contact angle (CA) with water was measured by a sessile drop method after laser irradiation. The CA varied with the increase of MP percentage used: 35.7±0.58, 119.4±0.87, 125.6±0.81 and 142.2±0.61 degrees, for 15, 25, 35 and 50% of MP, respectively. Evaluation of polar and dispersive components of superficial energy was performed by Owens and Wendt method [4] for liquids with different surface tensions and polarity. Taking into account that tube alignment and bulk structure of VACNT were maintained after each treatment, the wettability evolution was probably due to superficial chemical modification. The loss of the hydrophilic character is reasoned as the progressive removal of oxygen terminations from polar groups.

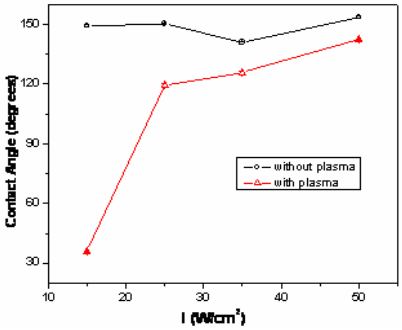

Figure 1: Relation between measured contact angle and Intensity of laser CO2 for VACNTS films treated with plasma and without plasma.

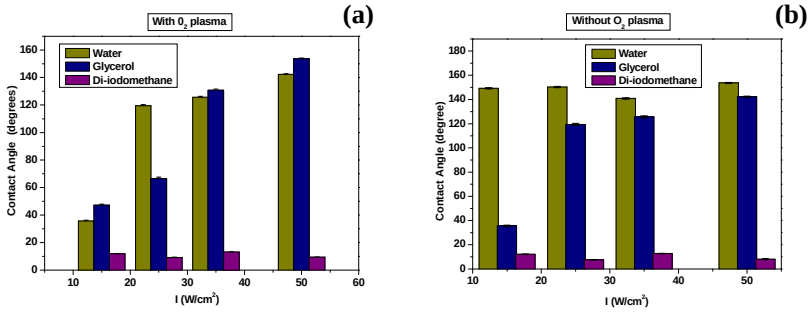

Figure 2: (a) Relation between measured contact angle and Intensity of laser CO_2 for VACNTS films treated with O2 plasma for different liquids and **(b)** Without O_2 plasma .

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