Thin Film Deposition Study of C_{60} on Silicon Wafers by Spin Casting

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Fullerene C_{60} has raised numerous studies since its discovery in 1985 [1]. Most of these studies have been aimed at the understanding of C_{60}'s chemical and physical properties as well as to purifying the diverse fullerene species [2]. Particularly, C_{60} thin films exhibit unusual and potentially useful properties, which can lead to technologically valuable applications such as low temperature superconductors or biosensors [3]. Therefore, the understanding of the dynamics and sticking properties of fullerenes is of paramount importance to those interested in the development of fullerene based structures. Most of C_{60} thin films are fabricated by evaporation and other techniques that require expensive equipment and precise process control. Here, we study the spin-coating deposition technique as a fast, simple and cost effective method to create thin fullerene coatings over pure silicon wafers. It has been previously reported in literature and also corroborated by our experiments that fullerene molecules tend to bundle together, which is mainly associated with the strong three-dimensional hydrophobic interactions between fullerene units [4]. Thus, different parameters such as solvent [5], sonicating and stirring time, post-annealing, spin speed [6], filtering or concentration have been considered in order to obtain a smooth and homogeneous C_{60} layer.

The solvent used, chlorobenzene, has lower saturation concentration than naphthalene and phenylene derivatives but it has been selected due to the fast evaporation time that allows skipping the post annealing process. The stirring and sonicating processes are required to prevent fullerenes from aggregation in the solution. However, different sonicating times between 5 minutes to 1 hour and stirring times between 2 hours and 24 hours have been explored without major changes. The filtering step is also necessary to keep the bigger aggregates away from being adsorbed directly on the substrate. In our case, two different filters of 200 nm and 20 nm have been probed without significant differences. When the spin speed is varied from 3,000 to 7,000 rpm, the fullerene average cluster height and width are linearly decreased. At the same time, the average cluster density per surface area is linearly increased together with the spin speed as it is shown in Figure 1. Nevertheless, the most important parameter is the concentration of the C_{60}/chlorobenzene solution. In Figure 2, it is shown that the average cluster height and width are exponentially decreased when the concentration is lowered from 4.0 to 0.05 mg/ml. In the same manner, the average cluster density per surface area is exponentially increased from 20 to more than 100 aggregates in a 5 μm^2 area when the concentration is varied from 4.0 to 0.05 mg/ml. This allows us to obtain a smooth thin fullerene C_{60} layer formed by small clumps of 8 nm and 150 nm average height and width respectively and homogeneously distributed all over the whole surface. Finally, it should be remarked that the concentration of C_{60} in the solution is the key parameter in the fabrication process of this coatings without underestimating the others.

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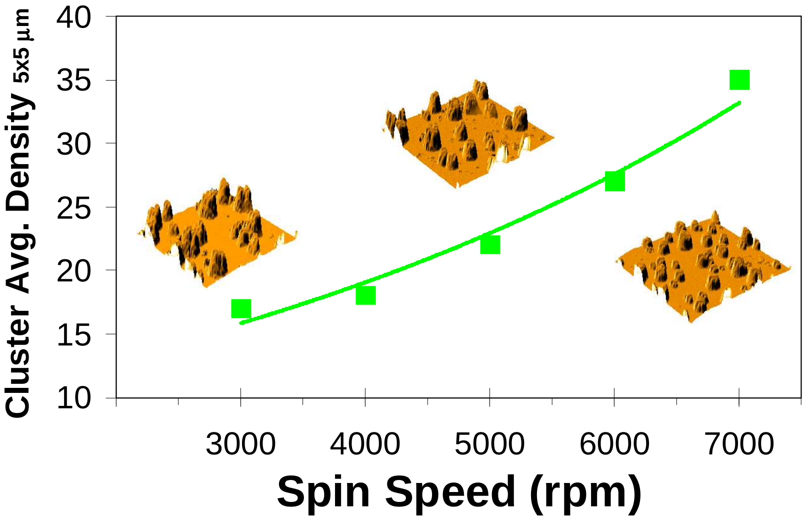

Fig1: Fullerene C_{60} clusters average density per surface area at diverse spin speed values.
Inset: 5x5µm AFM images

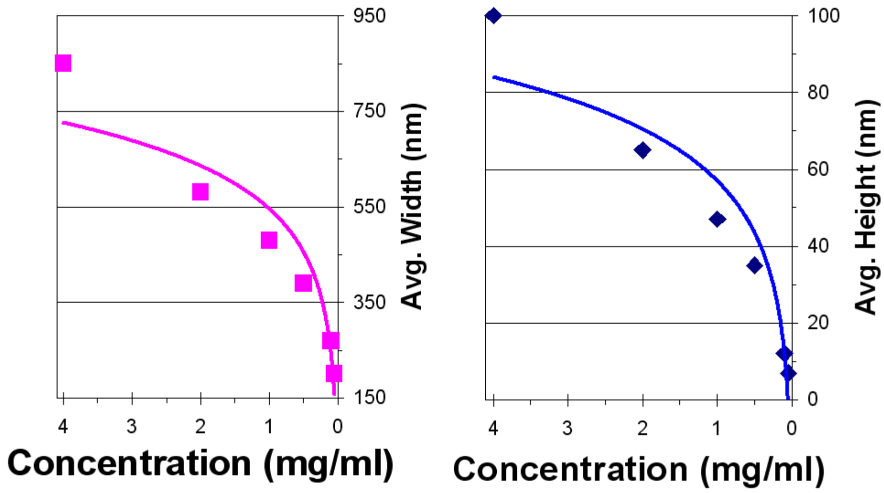

Fig 2: Fullerene C_{60} clusters average width and height at various concentration values.

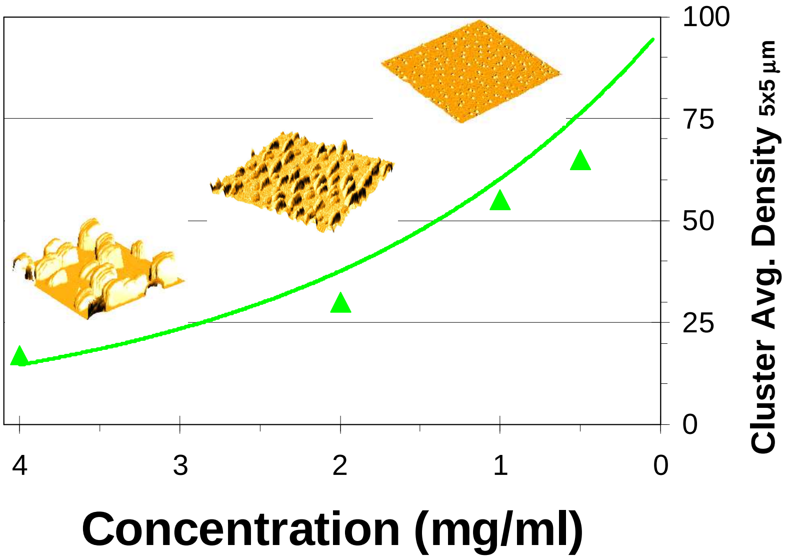

Fig 3: Fullerene C_{60} clusters average density per surface area at different concentrations.
Inset: 5x5µm AFM images