Application of C60 to improve the SPLEBL reference signal

C. R. Zamarreño[1], L. L. Cheong[2], E. Moon[2], H. I. Smith[2], I. R. Matias[1], F. J. Arregui[1]
[1]*Public University of Navarra, Campus Arrosadia S/N, Pamplona, Spain.*
[2] *Massachusetts Institute of Technology, 77 Massachusetts Av., Cambridge, MA.*

Spatial-Phase Locked Electron Beam Lithography (SPLEBL) [1] improves the traditional Scanning Electron Beam Lithography by placing a fiducial grid on top of the substrate and using the reference signal obtained from that grid to position the beam accurately. The fiducial grid fabrication process is a key factor in the SPLEBL system and it is required to be user friendly as well as not interfere with the e-beam resist. Furthermore, the fiducial grid should not block the normal e-beam exposures and provide a high signal to noise ratio. The changes in the reference signal are originated by the contrast in the secondary electron emission between the different materials used to fabricate the grid.

Here, we present a first approach to create the fiducial grid by using the fullerene C60 molecule [2]. C60 is a small molecule which has been proved to have a high secondary electron emission. Thus, using C60 to fabricate the fiducial grid will help to improve the signal to noise ratio and hence will increase the accuracy of the entire system.

It has been reported in literature and also confirmed by our experiments that the fullerenes tend to bundle together and the aggregate size depends primarily on the concentration of the solution, originating diverse C60 bunches. The fabrication process consisted of one single spin process [3] using diverse C60/chlorobenzene concentrations [4] over a previously patterned 250 nm period grid represented in Figure 1. The grid, shown in Figure 2, was fabricated using the interference lithography technique [5] and comprises a 10 nm Pt layer over silicon covered by a 20 nm SiO_2 layer. After the spinning processes it is observed a different behavior of the fullerene clusters depending on the C60 concentration used. First, with the highest concentration (2.0mg/ml), the fullerene clusters are attracted by the Pt holes of the grid and although some of them are too big to fit in the holes they are also centred on them as it is shown in Figure 3a. On the other hand, as it is shown in Figure 3b, when we use a lower C60 concentration (0.5mg/ml), the smaller aggregates are gathered on the small roughness features on the top of the SiO_2 layer, while the bigger clumps are collected by the Pt holes as was seen before. These results prove that the dynamics of the spin-casting fullerene layers are more dependent on the variations in the topography than on the materials of the surface. Finally, the fullerene clusters distribution illustrates the different behavior of the fullerene aggregates depending on their size, which suggests that a more accurate control of the clump size is required to produce a homogeneous C60 grid using this deposition technique.

---

[1] H. I. Smith, Physica E, **11(2-3)** (2001) 104
[2] K. M. Kadish, R. S. Ruoff, Wiley IEEE (2000)
[3] I. Belaish, I. Entin, R. Goffer, D. Davidov, H. Selig, J. P. McCauley, N. Coustel, J. E. Fischer, A. B. Smith III, J. Appl. Phys., **71(10)** (1992) 5248.
[4] V. N. Bezmel'nitsyn, A. V. Eletskiĭ, M. V. Okun', Physics-Uspekhi, **41(11)** (1998) 1091.
[5] T. B. O'Reilly, H. I. Smith, J. Vac. Sci. Technol. B, **26(1)** (2008) 128

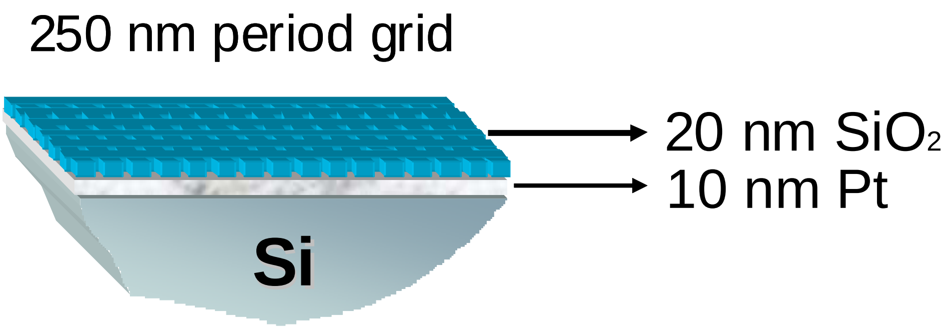

Fig 1: Schematic representation of the grid used to spin the fullerenes.

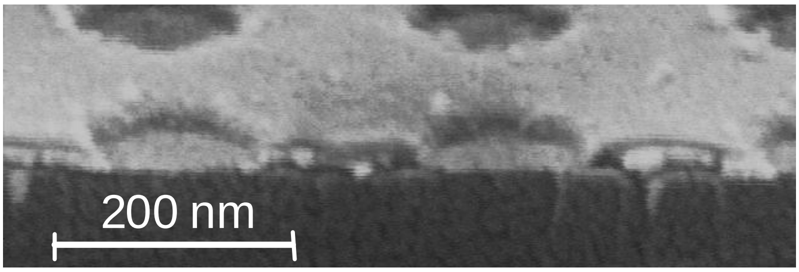

Fig 2: Scanning electron microscopy image of the grid used to spin the fullerenes.

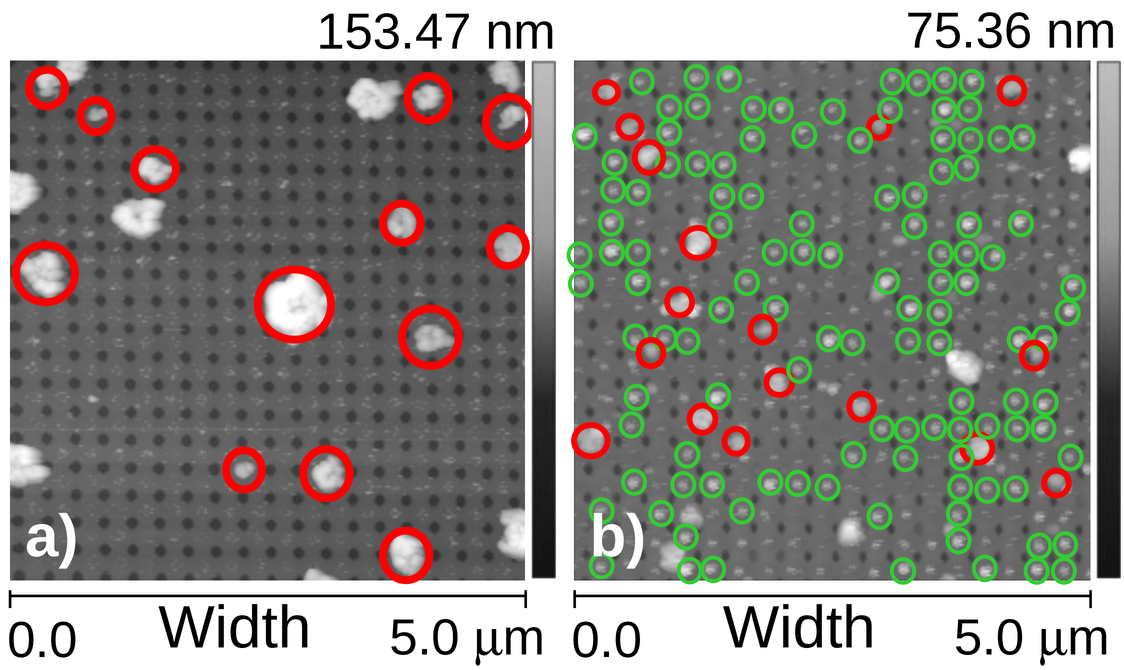

Fig 3: Atomic force microscopy images of the grids after spinning fullerenes using 2.0mg/ml, a), and 0.5 mg/ml, b), C60/chlorobenzene concentration. The red circles are surrounding the big aggregates centred on the holes and the green circles are surrounding the smaller aggregates concentrated on the small roughness features.