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Thin films of C_{60} produced by matrix-assisted pulsed laser evaporation (MAPLE)

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1. Introduction

Matrix-assisted pulsed laser deposition (MAPLE) is a technique to produce films of organic materials without destroying the molecules [1]. In MAPLE, a guest molecule, e.g., a polymer or a bio-organic molecule, usually in a concentration lower than 2 wt %, is dissolved and subsequently frozen into a light absorbing matrix. When this matrix is irradiated by the laser light, the solvent evaporates and the guest material, e.g., the organic molecules, is subsequently collected on a substrate. The achievement of good films of the guest material requires that i) the guest molecules do not decompose during the laser irradiation, that ii) few, if any, photoreactions occur and that iii) no matrix material is incorporated into the film.

MAPLE is typically used if the guest molecules need to be deposited in vacuum, for example on a film or a substrate which are sensitive to organic solvents and which cannot be produced by other techniques for organic materials, for example, spin coating. Typically, the average film thickness can be controlled much better by than other techniques and in many cases the film surface has been comparatively uniform.

While the two first conditions have been investigated regularly, very little work has been undertaken to investigate whether or not the films contain matrix material. As a matter of fact, the possible remnants of the matrix induce a high degree of non-uniformity in the films.

2. C_{60} films

The C_{60} molecule has well-characterized internal bonds, and its electronic excitation channels have been the subject of many studies. It is a stable molecule that interacts very little with most other molecules. The stability of fullerene is partially due to the high binding energy per carbon atom, which is around 7.4 eV [2].

An important application of thin layers of C_{60} is as active units in electronic devices, such as fullerene based solar cells. The buckminsterfullerene C_{60} is an electron acceptor and for photoinduced electron-transfer reactions, it is usually blended into electron-donating matrices with hole-conducting properties.

C_{60} is an ideal molecule to explore the limits of MAPLE for organic molecules. If C_{60} as a stable molecule with a high ionization potential, does not survive MAPLE transfer as an intact molecule, but decomposes into fragments, almost all other organic molecules will suffer from photofragmentation as well. It is also well suited for a study of the behavior of the matrix molecules on the substrate, since the chemical interaction between the C_{60} molecules and the matrix molecules is small because of the stable structure of C_{60}.

3. Results

The MAPLE target consisted of 0.67 wt. % C_{60} dissolved in anisole kept as a frozen disc. The laser fluence varied from 0.5 to 4 J/cm^2, and the films were deposited on Si- or KBr-substrates. The composition of the films was investigated by Fourier transform infrared spectroscopy. The surface morphology was studied with a Scanning Electron Microscope.

At fluences below 1 J/cm^2 FTIR spectroscopy does not show any trace of the matrix material anisole. However, at 1.5 J/cm^2 the surface is covered with microclusters and there is a significant signal of anisole in the spectrum. This can be interpreted as a result of strong ejection of micro-aggregates of matrix chunks with C_{60} molecules directly from the target as a result of explosive boiling. At low fluence the film is free of anisole and is essentially uniform except for nanoparticles of the size 10-30 nm in diameter. However, these nanoparticles originate probably from aggregates from the solution, before it was frozen. This interpretation agrees well with simulations of ablation of carbon nanotubes by MAPLE [3].

3. Conclusion

Uniform films of C_{60} were produced by MAPLE at low fluence. The results show that there is a strong correlation between rough surfaces with microclusters for films produced at higher fluence and remnants of the matrix in the films. Thus, moderate fluences below 1 J/cm^2 are preferable for the production of high quality films with MAPLE.

References

[1] D. B. Chrisey et al., Chem. Rev. **103** (2003) 553.
[2] S. Canulescu et al., Appl. Phys. A **104** (2011) 775.
[3] L. V. Zhigilei et al., Appl. Phys. A **105** (2011) 529.