Area-selective atomic-molecular layer deposition of lanthanide thin films on graphene

Aleksei Emelianov[1]
Kamila Mentel[1], Amr Ghazy[2], Anish Philip[2], Andreas Johansson[1], Maarit Karppinen[2], Mika Pettersson[1]
[1]*Department of Chemistry, Nanoscience Center, University of Jyväskylä, FI-40014 Jyväskylä, Finland,*
[2]*Department of Chemistry and Materials Science, School of Chemical Engineering, Aalto University, FI-00076 Aalto, Espoo, Finland*
emeliaa@jyu.fi

Area-selective atomic-molecular layer deposition (ALD/MLD) is a promising "bottom-up" alternative to the current nanopatterning techniques [1,2]. Due to the inherent 2-dimensional (2D) nature, the surface of graphene and other 2D materials do not provide sufficient reactive sites for chemisorption of ALD/MLD precursors compared with traditional microelectronics. Functionalization of certain surface areas is required to provide the selective growth of insulating materials. Recently, we overcame the chemical inertness of graphene to ALD precursors by local activation using direct femtosecond laser two-photon oxidation (TPO) [3] for selective ZnO deposition [4].
In this study, we guided the growth of Eu-organic thin films on top of single-layer graphene via TPO. We achieved high homogeneity (Figure 1a) and close to 100 % selectivity in locally activated predefined regions for Eu films up to 15 nm. The polymer used for graphene transfer highly affects the selectivity of the ALD/MLD process, as it might leave residues and promote unnecessary deposition in pristine graphene areas. The fabricated graphene/Eu-organic thin films exhibited high photoluminescence at 625 nm even when excited with a green laser (Figure 1b). These films are suitable for various applications such as fluorescent sensors or organic light-emitting diodes with small pixel sizes.

References

[1] G. N. Parsons, R. D. Clark, Chemistry of Materials, 32, 4920 (2020).
[2] J. Multia, M. Karppinen, Advanced Materials Interfaces, 9, 2200210 (2022).
[3] J. Aumanen, A. Johansson, J. Koivistoinen, P. Myllyperkiö, M. Pettersson, Nanoscale, 7, 2851 (2015).
[4] K. K. Mentel, A. V. Emelianov, A. Philip, A. Johansson, M. Karppinen, M. Pettersson, Advanced Materials Interfaces, 9, 2201110 (2022).

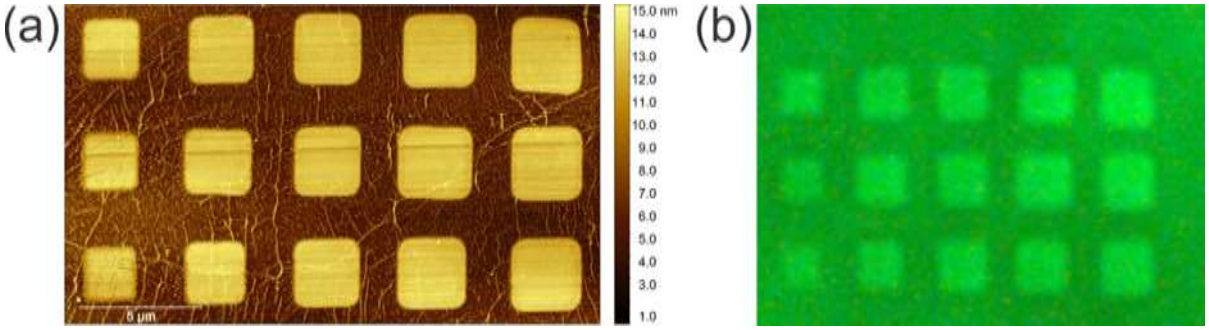

Figure 1: (a) AFM height image of Eu-organic film selectively deposited on predefined oxidized graphene patterns. (b) FLIM image of the same area excited by 514 nm laser with 20 µW power.