Applied Surface Science
Volume 252, Issue 15 , 30 May 2006, Pages 5462-5465
Proceedings of the Eight International Conference on Atomically Controlled Surfaces, Interfaces and Nanostructures and the Thirteenth International Congress on Thin Films - ACSIN8/ICTF13

doi:10.1016/j.apsusc.2005.12.033 Cite or Link Using DOI

Monitoring the ordering in biomolecular films on vicinal silicon surfaces by reflectance difference/anisotropy spectroscopy

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Available online 18 January 2006.

Abstract

DNA base molecules, adenine, thymine, guanine, and cytosine may be employed as charge transport molecules in biomolecular electronic devices. Their electronic properties are comparable with those of inorganic wide bandgap materials, e.g. GaN with the absorption onset in the near ultra-violet (UV) range. A recent field effect transistor study based on a modified DNA base revealed that the prototype bio-transistor gives rise to a better voltage gain compared to one based on carbon nanotubes (CNTs) [G. Mauricio, P. Visconti, V. Arima, S. D'Amico, A. Biasco, E. D'Amone, R. Cingolani, R. Rinaldi, Nanoletters 3 (2003) 479]. Here, in situ reflectance difference/anisotropy spectroscopy (RDS/RAS) is employed under ultra-high vacuum (UHV) conditions for monitoring the growth of DNA base molecules on vicinal hydrogen passivated Si(1 1 1) surfaces. Such vicinal substrates consisting of steps and terraces may serves as suitable templates for molecular ordering. Indeed, RDS/RAS measurements reveal information about molecular ordering of DNA bases induced by the density of steps on silicon surfaces. All four molecules, however, behave differently on the vicinal substrates. The first transition dipole moments corresponding to adenine and thymine molecules align mainly perpendicular to the step edge direction while for guanine and cytosine they align parallel to this direction, however, only in very thin layers. The RDS/RAS signal of the guanine and cytosine layers with thicknesses above 20 nm saturates due to a loss of ordering at higher coverages. Additionally, time-resolved RDS/RAS measurements at the silicon E_2 (4.25 eV) critical point (CP) demonstrate the sensitivity to the biomolecular/inorganic interface formation.

Keywords: DNA bases; Vicinal Si(1 1 1); Reflectance difference/anisotropy spectroscopy

PACS classification codes: 33.20.Kf; 68.47.Pe; 78.40.-q

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