VUV – Spectroscopic Ellipsometry Investigations of DNA Base Layers Grown onto Flat H-passivated Silicon Surfaces

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The DNA base molecules (guanine-G, cytosine-C, adenine-A, thymine-T ; *shown in Figure1*) may be considered as potential candidates in the field of nanotechnology. Their electronic properties are comparable to wide-gap semiconductors. Due to its low ionization potential, guanine is considered to be a key molecule for the enhancement of charge migration [1]. Guanine aggregates have been employed to build conducting nanoscale materials [2, 3]. Therefore the knowledge of the optical properties especially the dielectric function of DNA base layers is a prerequisite in the view of the above mentioned nanotechnological applications. Vacuum Ultraviolet (VUV) Spectroscopic Ellipsometry (SE) measurements were applied for the *in situ* optical characterization of DNA base layers grown onto flat H-passivated Si(111) surfaces. The DNA base layers were grown onto H-Si(111) surfaces by organic molecular beam deposition (OMBD) under ultra-high vacuum conditions. The silicon substrates were wet-chemically H-passivated by dipping in HF(40%) solution for 2 min. Such surfaces give rise to a (1x1) surface reconstruction. During the OMBD process H-Si(111) substrates were kept at room temperature. The VUV-SE measurements were performed at VUV ellipsometer either at 3m-NIM1 or 3m-NIM2 monochromators at BESSY II. The spectra were recorded in the energy range between 2.75 - 10 eV at an angle of incidence about 68°.

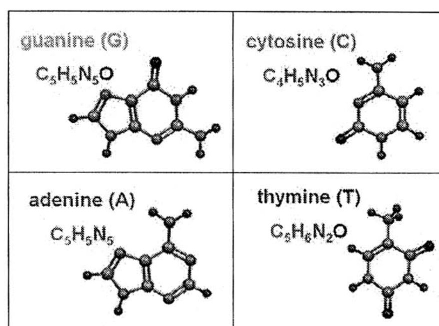

Figure 1. Chemical structure of DNA bases.

In the figure 2 the imaginary part of measured effective dielectric functions of DNA base layers on H-passivated Si(111) surfaces is shown. *Ex situ* FTIR measurements revealed that the organic layers are optically isotropic in the substrate plane as it was expected for the

3-fold symmetry of H-Si(111) surfaces. *In situ* VUV-SE measurements are limited to a single angle of incidence. For an accuracy determination of dielectric functions of DNA base layers a multi-sample analysis is required. Therefore different layer thicknesses were measured in order to compensate the variable incidence angle measurements. The layer thicknesses were determined from *ex situ* variable angle spectroscopy ellipsometry (VASE) spectra

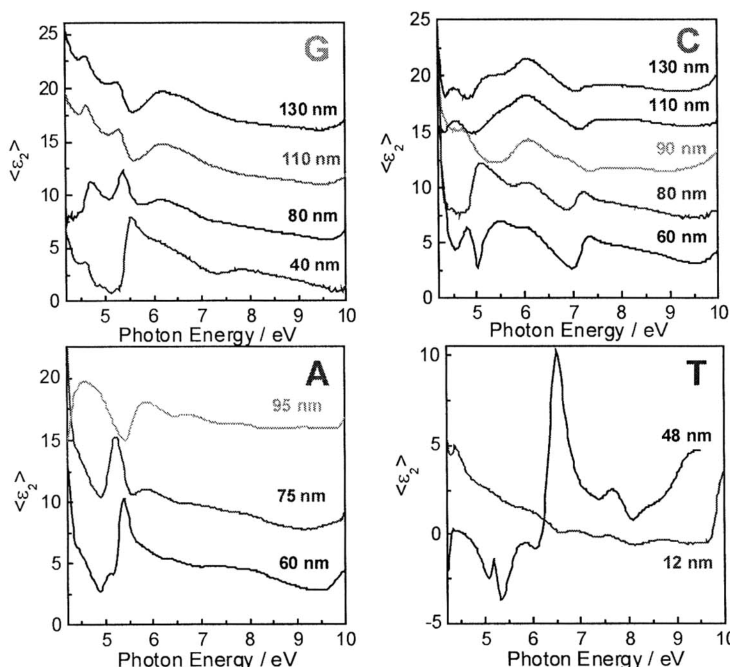

Figure 2. Measured effective dielectric function $<\varepsilon_2>$ of DNA bases (G, C, A, T) for different layer thicknesses on H-Si(111) surfaces.

assuming a Cauchy layer in the non-absorbing energy range between 0.8-2 eV. The organic layers start to absorb above 4.6 eV. For thinner layers than 60 nm the interference effects due to substrate absorption around 5.2 eV (E'_1 – the interbandgap transition in bulk Si) are present in VUV-SE spectra. In thicker layers the absorption of the organic overlayers dominates in VUV-SE spectra. The thymine layers are found to strongly depolarize the light due to a very rough morphology. Therefore thicker layers than 48 nm could not be measured. Even very low evaporation rate of 1Å/min could not prevent the roughness of the thymine layers.

Knowing that the organic layers are azimuthally optical isotropic the aim is to determine the dielectric functions by applying a uniaxial model using VASE program. The dielectric functions of DNA base layers have not been reported in literature so far.

References

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