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Change of Surface Electric Potential of UV-Irradiated P(VDF-TrFE) Nanolayer Deposited on Glass Substrate

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Summary
Influence of ultraviolet (UV) radiation on surface electric potential of 20– 25 nm thick P(VDF-TrFE 70:30) nanolayer consisting of 70% vinylidene fluoride (VDF) and 30% trifluoroethylene (TrFE) deposited on the glass substrate by Langmuir-Blodgett method was studied.

Introduction
P(VDF-TrFE) is a ferroelectric material that can change its polarization upon application of the external electric field. If such material is deposited onto glass substrate and irradiated with UV light, electric charge might be generated on dielectric glass substrate and this charge might change polarization of P(VDF-TrFE). Change of P(VDF-TrFE) polarization can depend on the length of UV exposure. The potential application of the effect is detection of UV radiation by ferroelectric P(VDF-TrFE) nanolayers deposited on glass substrates.

Methods
Polarization of P(VDF-TrFE) nanolayer was evaluated indirectly by measuring surface electric potential of the nanolayer with Kelvin probe force microscopy using Solver P47-PRO atomic force microscope (AFM).
Samples of bare glass substrate and P(VDF-TrFE) nanolayer deposited on the glass substrate were UV-irradiated with different irradiation steps, achieving 60 min total time of UV exposure. Irradiation steps 5, 12.5 and 20 min were used. Surface electric potential was measured after each step of the irradiation. To ensure that surface electric potential is always measured on the same area of the samples, irradiation with UV was done inside AFM. Control measurements without UV exposure were also made. In this case 5, 12.5 and 20 min were waiting intervals between AFM measurements, achieving 60 min total waiting time.
UV radiation was provided by HAMAMATSU PHOTONICS Lightningcare LC5 series xenon-mercury source L8222-01 (250–450 nm, with the central wavelength 365 nm). Distance between the surface of the sample and the output of the light guide of the UV source was 40 cm. The distance smaller than 40 cm resulted in heating of the sample surface.

Results

It has been found out that surface electric potential of both glass substrate and P(VDF-TrFE) decreases under the influence of UV radiation. The amount of the decrease depends on the irradiation step (Fig.1 (A–C), *X*-axis shows total time of UV exposure). Control group of samples shows that Kelvin probe force microscopy measurements themselves influence the changes of surface electric potential of both glass and P(VDF-TrFE).

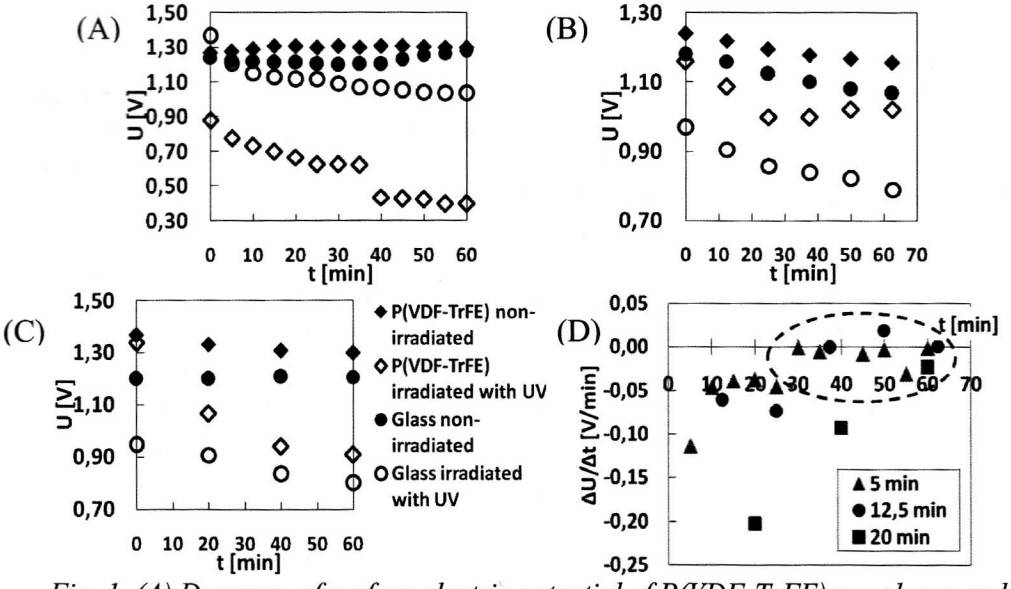

Fig. 1. (A) Decrease of surface electric potential of P(VDF-TrFE) nanolayer and glass substrate, irradiation step 5 min; (B) Decrease of surface electric potential of P(VDF-TrFE) nanolayer and glass substrate, irradiation step 12,5 min; (C) Decrease of surface electric potential of P(VDF-TrFE) nanolayer and glass substrate, irradiation step 20 min; (D) Velocity of the decrease of surface electric potential of P(VDF-TrFE) nanolayer for different irradiation steps

Velocity of the decrease of surface electric potential of P(VDF-TrFE) was calculated as $\Delta U/\Delta t=(U_{i+1}-U_i)/(t_{t+1}-t_i)$. Regardless of the irradiation step, surface electric potential of P(VDF-TrFE) stops decreasing after 30 min of total time of UV exposure which suggests that polarization of ferroelectric P(VDF-TrFE) nanolayer reaches its saturation (Fig.1(D)). Relaxation of surface electric potential of P(VDF-TrFE) to its initial value begins already in 10 minutes after UV radiation is turned off (not shown in the Figures).

Conclusion

UV radiation decreases surface electric potential of P(VDF-TrFE) nanolayer deposited on glass substrate. The amount of decrease depends on the irradiation step. P(VDF-TrFE) nanolayers are not able to keep the induced change of surface electric potential after UV irradiation is stopped.