Rasterkraftmikroskopische Untersuchung des Alterungsverhaltens von Polymermaterialien für solarthermische Anwendungen

Diplomarbeit

im Studiengang Wirtschaftsphysik

an der
Universität Ulm

erstellt am
Fraunhofer-Institut für Solare Energiesysteme ISE

vorgelegt von

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Bearbeitungszeitraum:	16.03.2010 - 15.09.2010

Freiburg, September 2010

Abstract AFM aging analysis of polymeric materials for solar thermal applications

The application of polymeric materials for solar thermal collectors provides a lot of advantages, particularly cost reduction and thus supports the propagation of this technology. Though, durability of polymeric materials is crucial and assessment methods based on scientific ageing analysis are necessary.

The objective of this study was to analyse the degradation impacts of temperature, humidity and UV irradiation on selected material samples. These were extruded plates of PPS, PPE/PS and PP with 10% graphite (PP-G10). AFM Tapping Mode was used to gain information about topographic changes. Force Distance Curve technique (FDC) as well as Pulsed Force Mode (PFM) were employed and allowed the analysis of mechanical properties of the surface.

To obtain reproducible aging states, an artificial aging in climate cabinets was carried out. Six degradation factor combinations were defined as “damp heat”, “damp heat UV”, “heat UV”, “UV”, “heat 85” and “heat 120” with damp = 85% r.h., heat (85) = 85°C, heat 120 = 120°C and UV = UV irradiation. Besides the unaged test specimens, samples with 125h, 250h and 500h exposure time were procured.

The heat UV test caused on PPS and PPE/PS within 500h strong blooming effects which aggravated with time. The damp heat UV test led on PPS to a strong bleeding, measurable already after 24h and on PPE/PS to an in its magnitude limited blooming where a stable status was reached after 250h. The UV test shows a flattening effect on PPS as well as on PPE/PS where additionally high and spiky elevations occured after 500h. The damp heat test didn’t induce noticeable changes except a low smoothing on PPS. After the heat tests movable particles, supposed to be residua from older tests, showed up on the surfaces.

On the PP-G10 samples a loss of the characteristic surface structure was detected in all tests except the damp heat UV test, where small craterlike damages of the surface could be distinguished. In the heat UV test, micro cracks were found after 250h exposure time and indications of micro cracks were visible on PP-G10 after 100h UV test.

It was found that the stiffness analysis made with PFM is more accurate than with FDC. With the former it was possible to determine dimensions of stiffness change: The damp heat and the damp heat UV tests had induced on PPE/PS after 500h a softening of at least 3% and 51% respectively. For the Damp heat UV and heat 85 tests a hardening was identified of at least 13% and 20% respectively. In the case of addition of UV irradiation to damp heat treatment a hardening influence could be detected, whereas the addition to heat treatment effects a softening.

The application of the developed methods shows that AFM techniques provide a broad information resource to investigate polymer aging. It gives the basis for a methodological advancement and the support of durability assessments.