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Digital Pulsed Force Mode - Adhesion and Separation Mode

Investigation of Adhesive Tape Properties

For the development of adhesive tapes and films, fundamental knowledge of adhesive properties on the microscopic scale is essential. This is especially important for removable adhesive films such as those for protecting the paint of new cars. These materials require two properties that are normally mutually exclusive. On one hand, a maximum adhesive force is desired, on the other hand, the adhesive tape should be easily removable without leaving residue on the surface. Beyond macroscopic inspection, specialized instrumentation is required to determine the degree to which these characteristics have been reconciled. With Atomic Force Microscopy (AFM) and the Digital Pulsed Force Mode, such detailed measurements can be easily performed.

The topography of an adhesive film was imaged under the control of the Digital Pulsed Force Mode. By simultaneously measuring and storing force curves over the entire scan range, information about the interaction between sample and probe was obtained. Areas of interest on the pulsed force curves were evaluated and imaged during the scan and then investigated further following its completion. This was possible because the software of the Digital Pulsed Force Mode preserves the association between the position on the sample and its corresponding force curve.
The images show the results of such an investigation with a focus on adhesion and separation(brighter colors represent higher values).

The topography of the adhesive side of the sample is shown in Fig. 1. It can be seen that on the microscopic scale, the adhesive film consists of at least two different phases.The adhesion image (Fig. 2) shows pronounced differences in the adhesive properties of the two phases and also some linear structures that were not apparent in the topography.

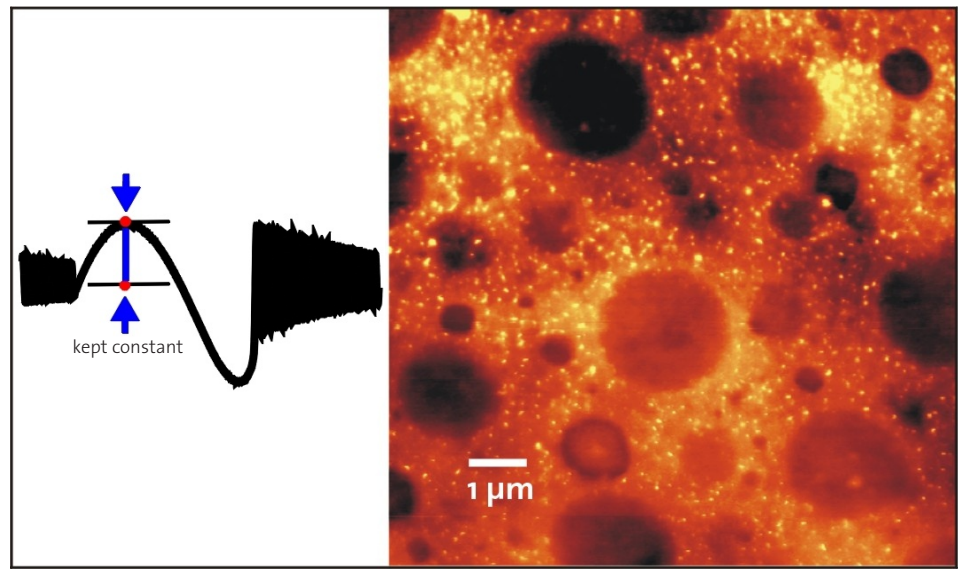

Fig. 1: Topography of an Adhesive Tape, Total scale: 115 nm, Scan range: 10 x 10 µm

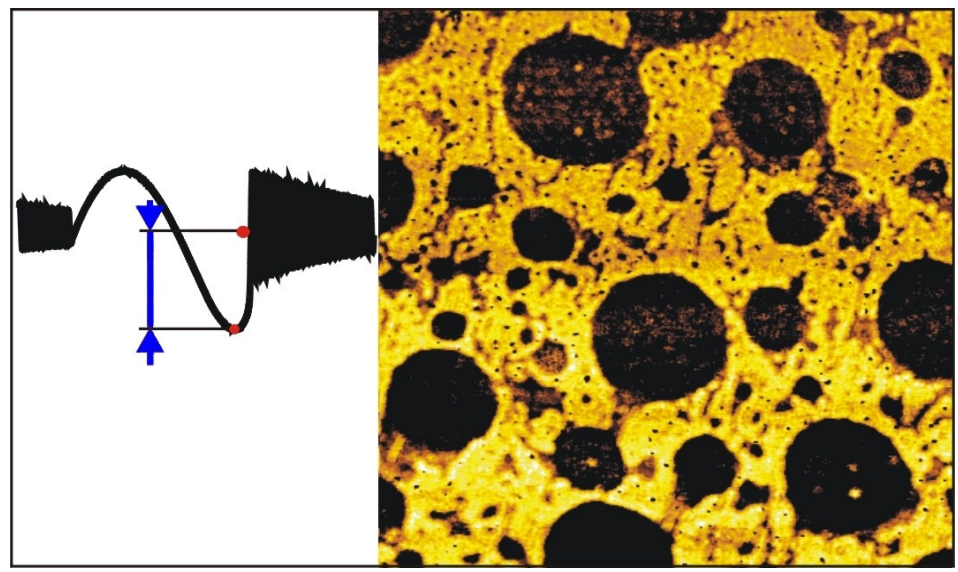

Fig. 2: Adhesion Force

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It is also possible to image the energetic proportions of adhesion and separation. Fig. 3 shows the adhesion energy , Fig. 4 represents the separation energy of the adhesive material. The corresponding area of the pulsed force curve is shown for clarity.

In addition to the maximum adhesive force, the adhesive energy is also investigated. Due to the viscous behavior of the adhesive material, the detachment of the film from the surface depends not only on the adhesive force, but also on the adhesive energy of the contact region. Therefore, the area under the adhesion peak is evaluated because it is linked to this energy. It is notable that the area to the right of the adhesion peak shows the inverse contrast of the total area under the adhesion peak.

In conclusion, it was shown that the AFM and the Digital Pulsed Force Mode enable the investigation of adhesive tapes in detail. The acquired data was not restricted to topographical properties. Formerly inaccessible properties such as adhesion energy and separation energy can be measured with the evaluation functions of the DPFM. Information concerning these microscopic characteristics guides the development of adhesive tapes. Therefore, Atomic Force Microscopy under control of the Digital Pulsed Force Mode is an ideal tool to investigate the surface properties of such materials.

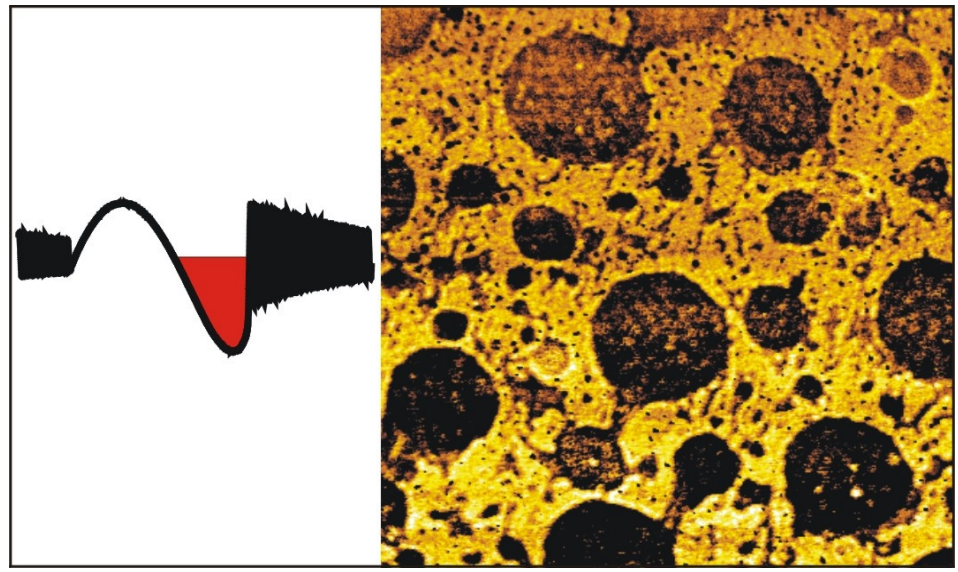

Fig. 3: Adhesion Energy

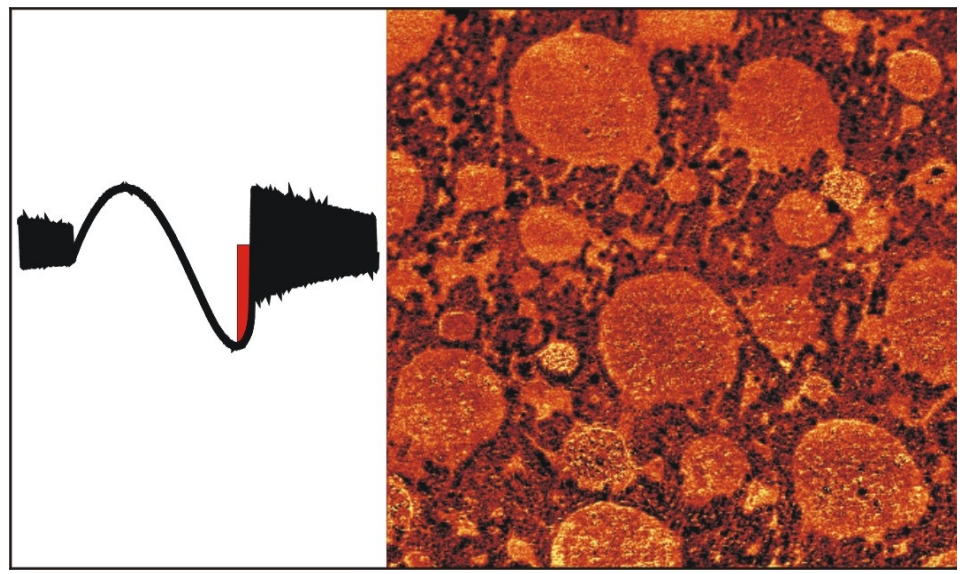

Fig. 4: Separation Energy