

Scanning Kelvin Probe Force Microscopy - Chances and Limitations for In-Situ Delamination Studies

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Scanning Kelvin Probe Force Microscopy (SKPFM) has been developed as a powerful tool for the investigation of microelectronic devices as well as detection of reactivity of intermetallic particles /1-3/. However, little effort was made in using the SKPFM for in-situ measurements of delamination processes. In many industrial applications improved stability of metal/polymer composites concerning adhesion and corrosion is of current interest. This stability is mainly determined by the interface of the composite system where a sudden change in the mechanical and electrochemical properties occurs.

The delamination of a metal/organic coating system starting from a defect can be monitored in-situ by means of the scanning Kelvin probe technique /4/. The potential measured in the defect area is determined by the corrosion potential of the active metal surface whereas the potential of the intact interface is determined by the inhibited surface. The potential drop between the active and passive interface is the designated delamination front. The delamination process results from the destruction of the interface between metal and coating by radical intermediates generated by the oxygen reduction. A prerequisite for delamination is the migration of, for example, Na^+ ions, to close the electrical circuit between the delamination front and defect. To date, the lateral resolution of the Scanning Kelvin Probe (SKP) has been limited by the diameter of the probe (20-100 μm) and the rather large working distance (about 10 μm) between the probe and sample.

SKPFM permits potential measurements with a higher lateral resolution, which is mainly dependent on the tip to sample distance as determined by the Scanning Force Microscopy technique (nanometers to about 2 μm) and the tip shape. Topography data of the same scan area is simultaneously recorded. This offers the possibility to measure the surface and interface behaviour with a high lateral resolution.

For in-situ investigations of mesoscopic delamination effects, specially designed samples were used and a humidity chamber was built. Film thicknesses of some tens of nanometers were used for the organic coatings /5/. Compared to SKP delamination measurements, an extremely sharp potential drop over ca. 10 μm was detected (see Fig.1). This points to the theory of a much sharper separation between localised electrochemical processes than expected from the SKP. Surface analytical data such as TOF-SIMS and small spot ESCA supported the SKPFM data. The typical element distribution for cathodic delamination was also found. In the delaminated area a higher concentration of Na^+ ions was found in comparison to the delamination front (ca. 10 μm wide) where the concentration was significantly lower (see Fig.2). In the intact area, no Na^+ ions could be found. The delaminated area did not contain Cl^- ions within a distance

of more than 1mm from the defect. These results for the ultrathin organic coatings are in good agreement with the theory of cathodic delamination developed for coatings with much higher thickness.

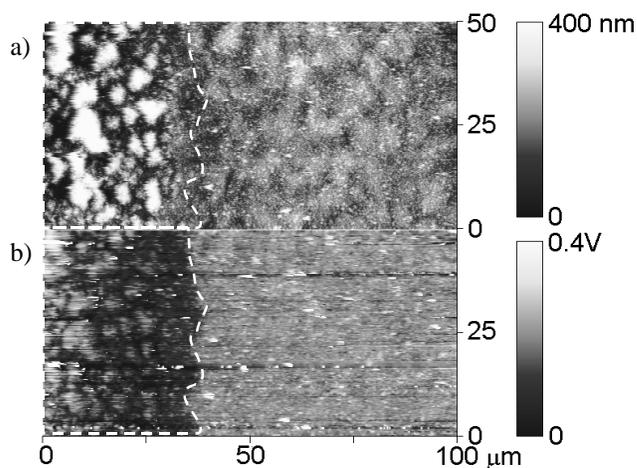


Figure 1: In-situ delamination SKPFM on a plasma polymer coated gold surface. Direction of delamination: left \rightarrow right. a) Topography; b) Potential

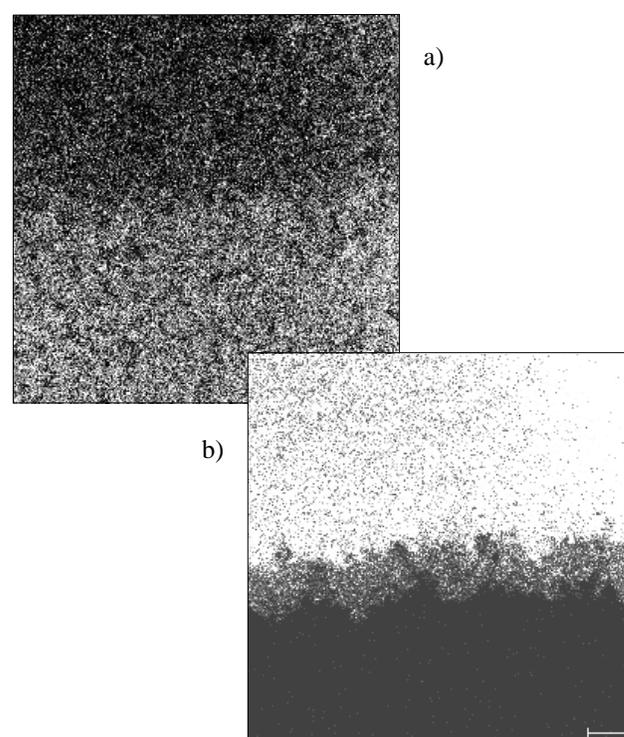


Figure 2: TOF-SIMS scan over the delamination front – delaminated area top, intact area bottom; 100 x 100 μm scan area. a) Au^+ distribution; b) Na^+ distribution

References

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