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On the use of scanning Kelvin probe for assessing *in situ* the delamination of adhesively bonded joints

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OVERVIEW AND MOTIVATION

Adhesive Bonding Technology

Indispensable technology for many industries

Bond dissimilar materials | Efficient load transfer | Function integration

Figures 1 and 2: Automated adhesive bonding of a frame onto a CFRP aircraft fuselage (left). Car headlight with bonded front glass-adhesive curing via microwaves (right).

Hard to predict the lifetime of bonded components when exposed to moisture and corrosive environment

- Water may reduce the joint strength and introduce stresses
- A significant cause of joint weakening is the effect of water and ions in the interface between adhesive and substrates

Knowing the behavior of corrosive media in adhesive joints

Greater confidence | Increase the use of adhesives in industry | Directing the design

Scanning Kelvin Probe - SKP

Contact potential difference and topography | Non contact and non destructive | Possible to measure through an insulating film

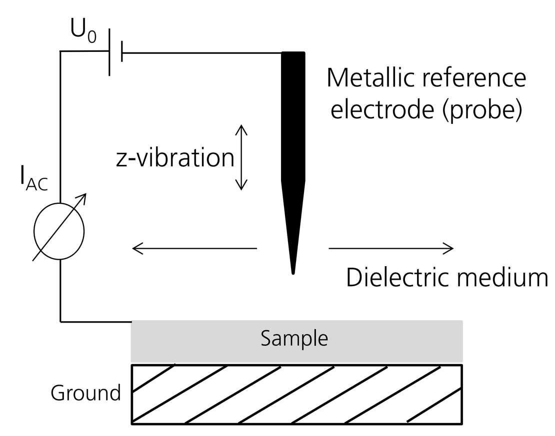

Figure 3: Schematic structure of a scanning Kelvin probe.

It is a powerful and established method that can detect *in situ* the delamination of polymer coated materials. The SKP detects potential changes due to the incorporation of ions into the metal/polymer interface [1].

MAIN OBJECTIVES

- Use similar approach of organic coating delamination experiments [1,2] to study adhesively bonded joints
- Describe a model of the delamination in an adhesive joint

RESULTS

SKP delamination measurements

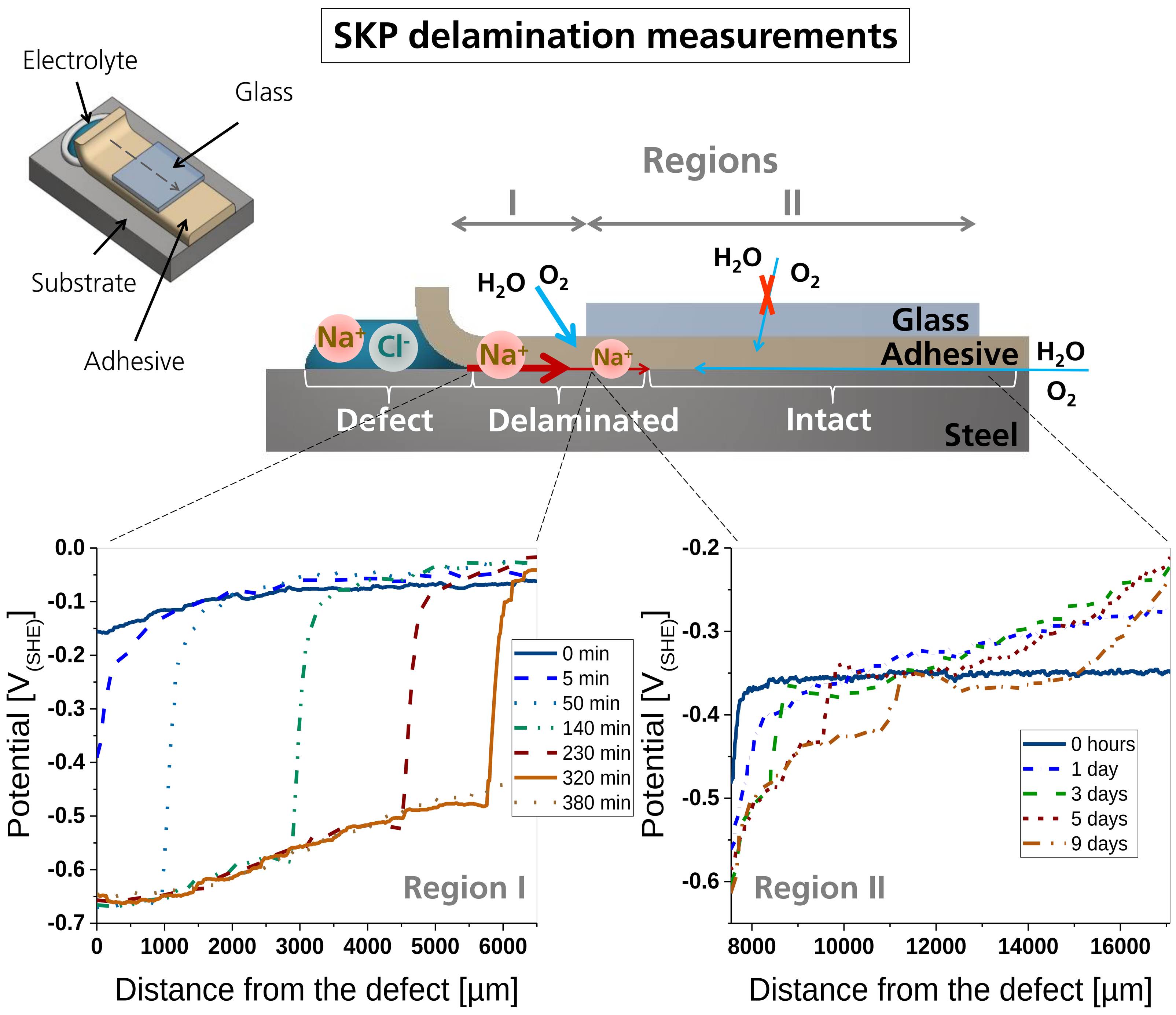

Figure 4. Top part: lateral view of the sample sketch, showing region I and II, representing an open and a closed joint geometry, respectively. Bottom part: typical potential distributions for the open joint (region I, left side) and closed joint (region II, right side) with total measurement time of 380 min and 9 days, respectively. (Electrolyte on the defect: 0.5M NaCl).

Measurements details

Tip material: stainless steel, tip diameter: 100µm, tip/sample average distance: 30µm, humidity: >95%r.h., temperature: RT.
Substrate: non-alloy steel, adhesive: aqueous dispersion of a polymer based on: acrylic ester and styrene, glass: aluminoborosilicate.

Delamination rates

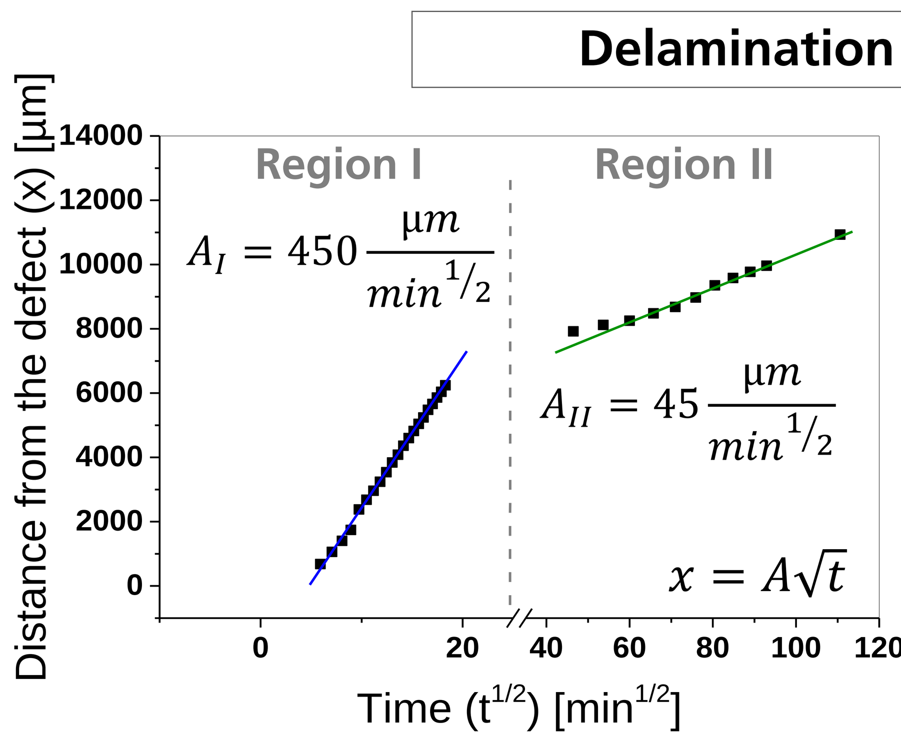

Figure 5 : Plot of the distance from the defect vs. square root of time for the regions I and II and the calculated slopes (A) of the fitted curves. The values were obtained from the differentiated potential profiles in figure 4.

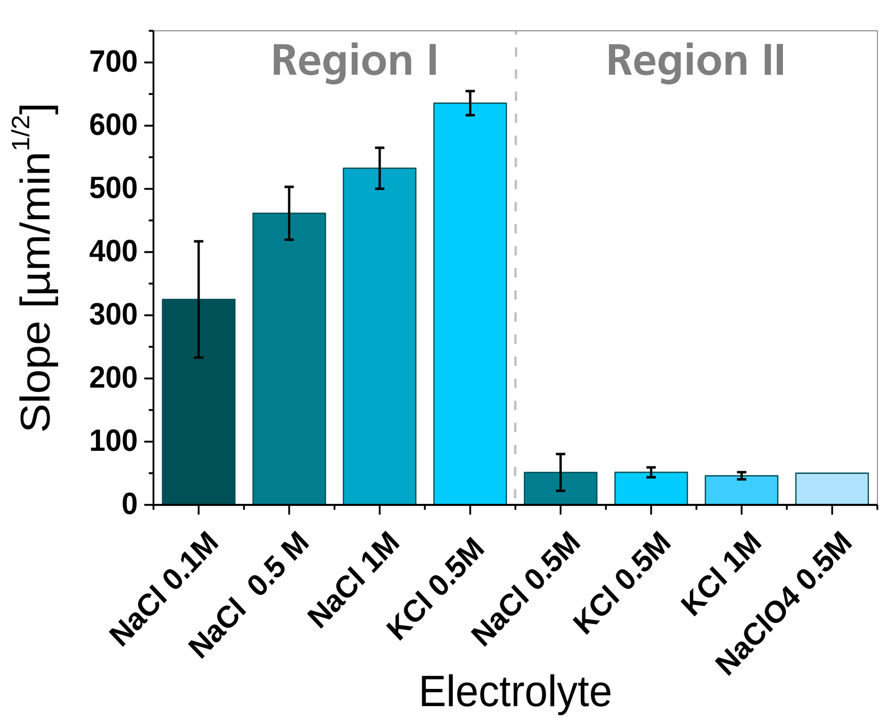

Figure 6: Comparison of the delamination kinetics (average and standard deviation of the slopes (A)) for samples whose defects have been filled with 0.1, 0.5 and 1M solutions of NaCl, KCl or $NaClO_4$.

Ion distribution

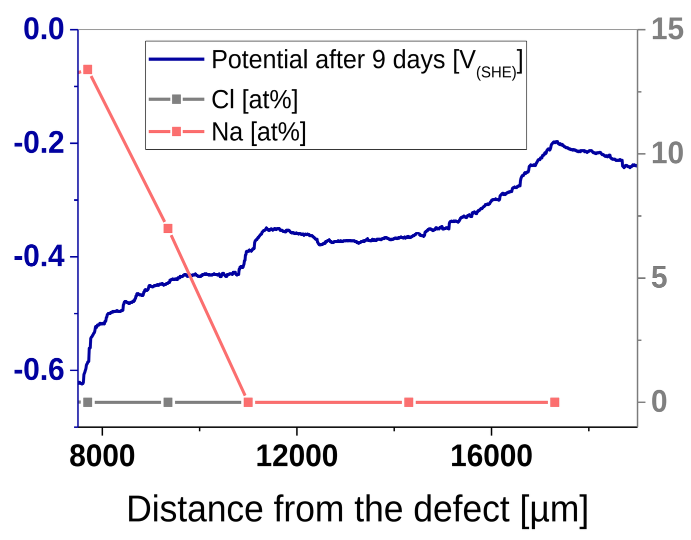

Figure 7: Potential map of the region II after 9 days and ions (Na, Cl) distribution (XPS results) after removing the adhesive and glass.

CONCLUSIONS

- It is possible to observe *in situ* the ageing relevant processes at the interphase of an adhesive joint by means of scanning Kelvin probe
- The mobility of hydrated cations in the closed joint (region II) was found to be ten times slower than in the open joint geometry (region I)
- The delamination rate determining step for the closed joint geometry (region II) is not the transport of ions at the interphase

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