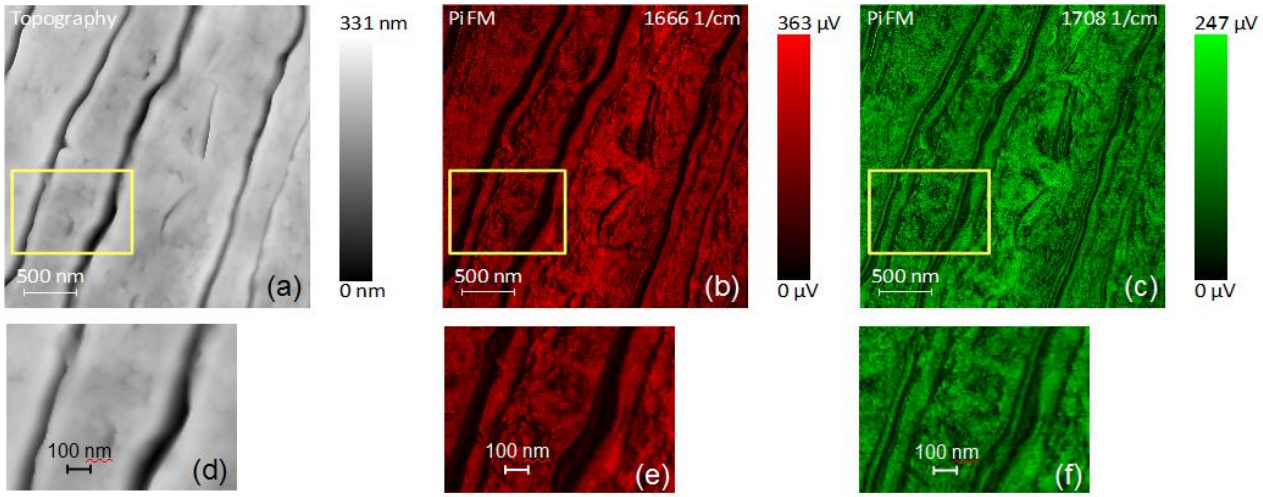
Non-destructive nm-scale Chemical Analysis for Soft Materials and Life Science by Photo-Induced Force Microscopy

Anne-D. Müller[1], Derek Nowak[2], Eckart Rühl[3]

[1]*Anfatec Instruments AG, Melanchthonstr. 28, 08606 Oelsnitz, Germany.*
[2]*Molecular Vista Inc.,* 6840 Via Del Oro, San Jose, CA 95119, *U.S.A.*
[3]*Physical Chemistry, Freie Universität Berlin, Takustr. 3, 14195 Berlin, Germany*

Photo-induced Force Microscopy (PiFM) is an emerging technique that combines the advantage of a very high spatial resolution in atomic force microscopy (AFM) with the chemical selectivity of infrared spectroscopy. This contribution explains the physical background and technical aspects of PiFM extracting the key features of the method, such as the very high surface sensitivity, its information depth and sensitivity for very small amounts of material to be analyzed even on very delicate surfaces.
In the second part of the contribution, results on polymer mixtures, thin organic films and single molecules are presented. These examples highlight the spatial resolution, the imaging capabilities and chemical detection limits on very soft surfaces or thin layers.[1]
Instancing PiFM's advantages in life-science applications, this contribution highlights the capability of selective label-free probing on fixed human skin samples that were penetrated by topically applied dexamethasone. In these cross-sectional prepared skin slices of 300 nm thickness, dexamethasone is primarily found in the stratum corneum, but also in the viable epidermis. The figure shows that topically applied dexamethasone finally penetrates into the lipid lamellae between the corneocytes and fills them partially.



Detailed view on the stratum corneum of fixed human skin: (a) AFM topography visualizing the structure of corneocytes; (b) chemical PiFM contrast related to amides probed at 1666 cm^{-1}; (c) PiFM contrast related to dexamethasone. Figures (d)-(f) show an enlarged view of the regions indicated by a yellow box in (a)-(c).

The spatial resolution of PiFM goes beyond the resolution of other chemically sensitive imaging techniques such as X-ray microscopy, micro-Raman analysis and any other scanning focal optical analysis. Consequently, it helps to better understand the interactions between medical treatments and healing processes or between drug location inside a cell and drug efficacy. Being able to apply this capability even on very soft and eventually water covered surfaces with very rough surface corrugations, PiFM becomes a extremely interesting analysis method for life science and medical research.

References

[1] D. Nowak et al., Sci. Adv. **2**, e1501571 (2016).