Pattern recognition in NC-AFM images in liquid

Farzin Irandoost[1#], Filippo Federici Canova[2], Tobias Dickbreder[3], Franziska Sabath[4], Takeshi Fukuma[5], Angelika Kühnle[6], and Adam S. Foster[1,5]

[1] Department of Applied Physics, Aalto University; Espoo 02150, Finland
[2] Nanolayers Research Computing Ltd., London NW9 6PL, England
[3] Department of Physical Chemistry, University of Vienna, Vienna, Austria
[4] Department of Physics at Interfaces Max Planck Institute for Polymer Research, Germany
[5] Nano Life Science Institute (WPI-NanoLSI), Kanazawa University; Kanazawa 920-1119, Japan
[6] Physical Chemistry I, Bielefeld University, Bielefeld, Germany

farzin.irandoost@aalto.fi

In-liquid NC-AFM imaging of periodic crystals, such as calcite, often reveals varying hydration patterns, although the sample remains unchanged. These variations arise from factors like tip and imaging height [1,2], and while expert eyes can distinguish between them, there is a gap for a systematic and quantitative approach.

In the current study, firstly, we developed an algorithm to extract features from such periodic patterns using Fourier transforms (FT). While FT provides a solid mathematical background to analyze ideal periodic patterns, practical challenges—such as noise in the data and low resolution—must be tackled. After establishing FT-based descriptors, we implemented a workflow for automated pattern recognition, leveraging clustering algorithms for large calcite datasets.

In this work, we present our method to utilize FT-based analysis for describing calcite patterns in NC-AFM data. Our tool offers extensive processing and correction options, allowing experimentalists to adjust analyses depending on their data or application. It also reduces the computational demands, enabling the automated recognition of patterns in large image datasets. In the end, we will present current findings from the analysis of hydration patterns on different surfaces to identify the tip.

References:

1. Fukuma, T., Reischl, B., Kobayashi, N., Spijker, P., Canova, F. F., Miyazawa, K. & Foster, A. S. Phys. Rev. B 92, 155412 (15 2015).
2. Miyazawa, K., Tracey, J., Reischl, B., Spijker, P., Foster, A. S., Rohl, A. L. & Fukuma, T. Nanoscale 12, 12856–12868 (24 2020).