

## **Title: Reference system for scanning probe tip fingerprinting**

### **Authors:**

**Robert Turansky**  
(Institute of Physics, Slovak Academy of Sciences)

Joseph Bamidele  
(Dept. of Physics, King's College London)

Yasuhiro Sugawara  
(Dept. of Applied Physics, Osaka University)

Ivan Stich  
(Institute of Physics, Slovak Academy of Sciences)

Lev Kantorovitch  
(Dept. of Physics, King's College London)

Knowledge of the chemical structure of the tip asperity in Non-Contact Atomic Force Microscopy (NC-AFM) is crucial as controlled manipulation of atoms and/or molecules on surfaces can only be performed if this information is available. However, a simple and robust protocol for ensuring a specific tip termination has not yet been developed. We propose a procedure for chemical tip fingerprinting and an example of a reference system, the oxygen-terminated Cu(110) surface, that enables one to ensure a specific tip termination with Si, Cu, or O atoms. To follow this up and unambiguously determine tip types, we performed a theoretical DFT study of the line scans with the tip models in question and found that the tip characterization made based on experimental results (Cu/O-terminated tip imaging Cu/O atoms) is in fact incorrect and the opposite is true (Cu/O-terminated tip imaging O/Cu atoms). This protocol allows the tip asperity's chemical structure to be verified and established both before as well as at any stage of the manipulation experiment when numerous tip changes may take place.

Financial support from APVT (ESF-EC-0007-07) under the Nanoparma ESF FANAS project is gratefully acknowledged. This research was supported in part by ERDFOPR&D, Project CE QUTE ITMS 26240120009, and via CE SAS QUTE.