Combining AFM and SEM Techniques: An example on the investigation of dislocation processes in small scale plasticity

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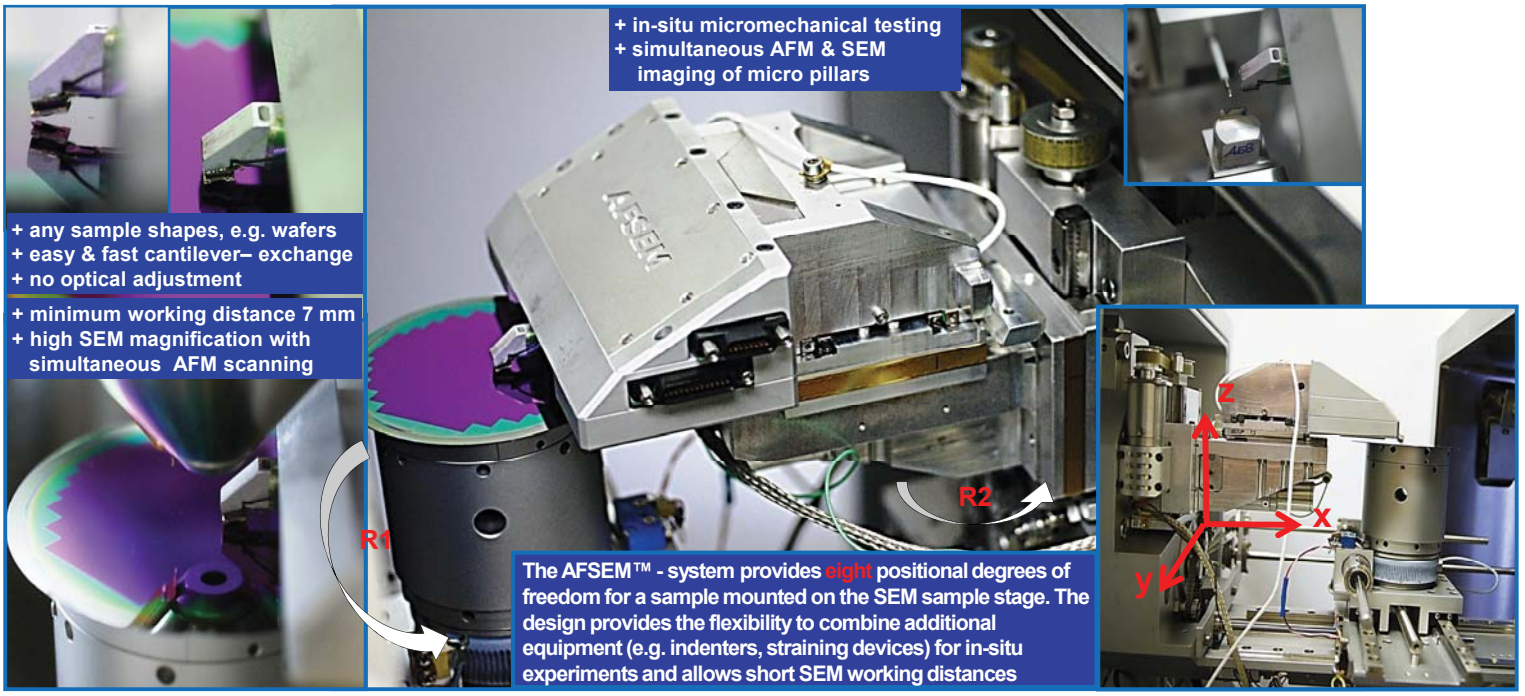
Abstract

Many advantages arise with the combined imaging capabilities of the atomic force microscope (AFM) and the scanning electron microscope (SEM). **AFSEM™** is optimized for co-localized AFM/SEM imaging for in-situ micromechanical testing and complex sample geometries. The precision cantilever positioning under SEM control is especially important for imaging micro-sized pillars and beams where improper positioning could lead to destruction of the sample or damage of the cantilever tip. The special design of the scanner and the cantilever holder allows short SEM working distances as low as 7mm permitting high resolution SEM imaging during simultaneous AFM scanning. First quantitative step-height measurements on a deformed single crystal Cu-Zn samples demonstrate the benefits of the system.

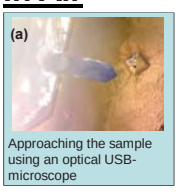
AFSEM™ Concept



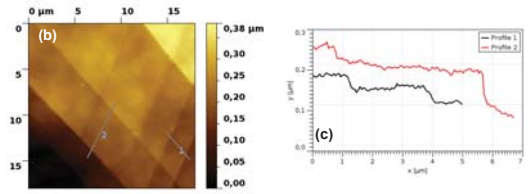
Slip steps on Brass in Air and in Vacuum

Investigation of slip steps surrounding Vickers indents, made on an electropolished single crystal Cu-15%Zn.

In Air



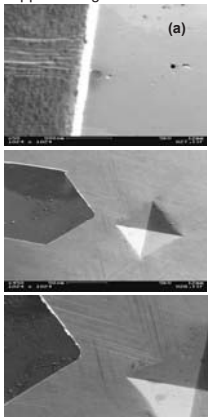
Approaching the sample using an optical USB-microscope



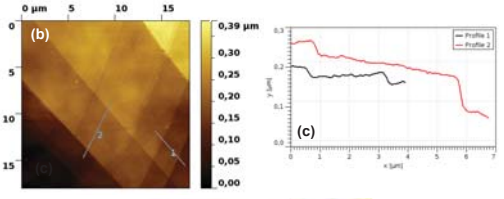
After bringing the tip of the cantilever to the position of interest (a) the sample is scanned (b). Cross sections of the 2D-Scan are shown in (c). Height of slip steps: Profile 1: 30nm, 43nm, profile 2: 31nm, 84nm. A 3D-Graph of the scan is shown in (d)

In Vacuum

Approaching inside the SEM

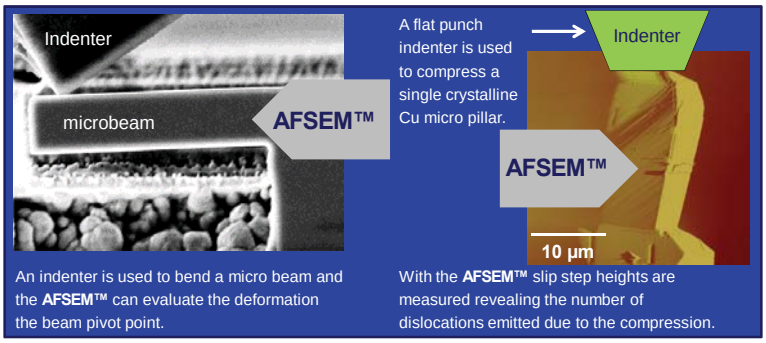


The position of interest is found by SEM-imaging (a). The flattened AFM scan (b) is again analyzed by cross sections at the same position (c). A 3D scan is shown in (d). Height of slip steps: Profile 1: 24nm, 37nm, profile 2: 35nm, 93nm



Planned in-situ Applications

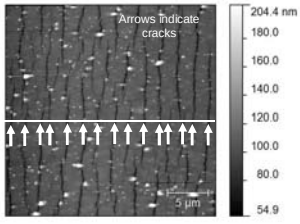
Small scale plasticity mechanisms can be studied using the **AFSEM™** combined with micro beam bending experiments and micro pillar compression experiments inside the SEM



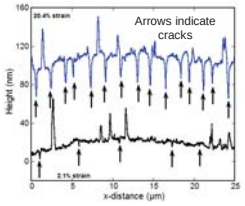
An indenter is used to bend a micro beam and the **AFSEM™** can evaluate the deformation the beam pivot point.

With the **AFSEM™** slip step heights are measured revealing the number of dislocations emitted due to the compression.

Ductile thin film deformation under tensile strain can be observed better with AFM and localized deformation and cracking can be clearly distinguished.



A 50 nm Cu film on Polyimide substrate is strain in tension. The resulting deformation and fracture is easily observed with AFM. See neighboring poster for more information.



Conclusions

- We have successfully integrated a tip scan AFM inside an SEM with:
  - In-situ micromechanical testing with AFM tip positioning under SEM control
  - Wide range of sample geometries with a simple mounting mechanism
  - 8 positioning degrees of freedom and 7mm minimum working distance
- Same results for in air and in vacuum experiments

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