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A masking technique to perform high accuracy diffraction experiments on FIB-machined specimens

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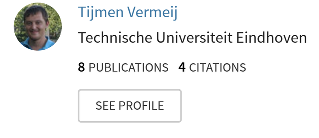

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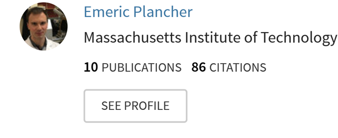

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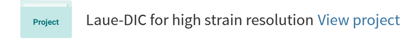

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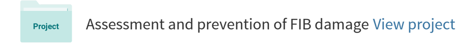

Assessment and prevention of FIB damage View project

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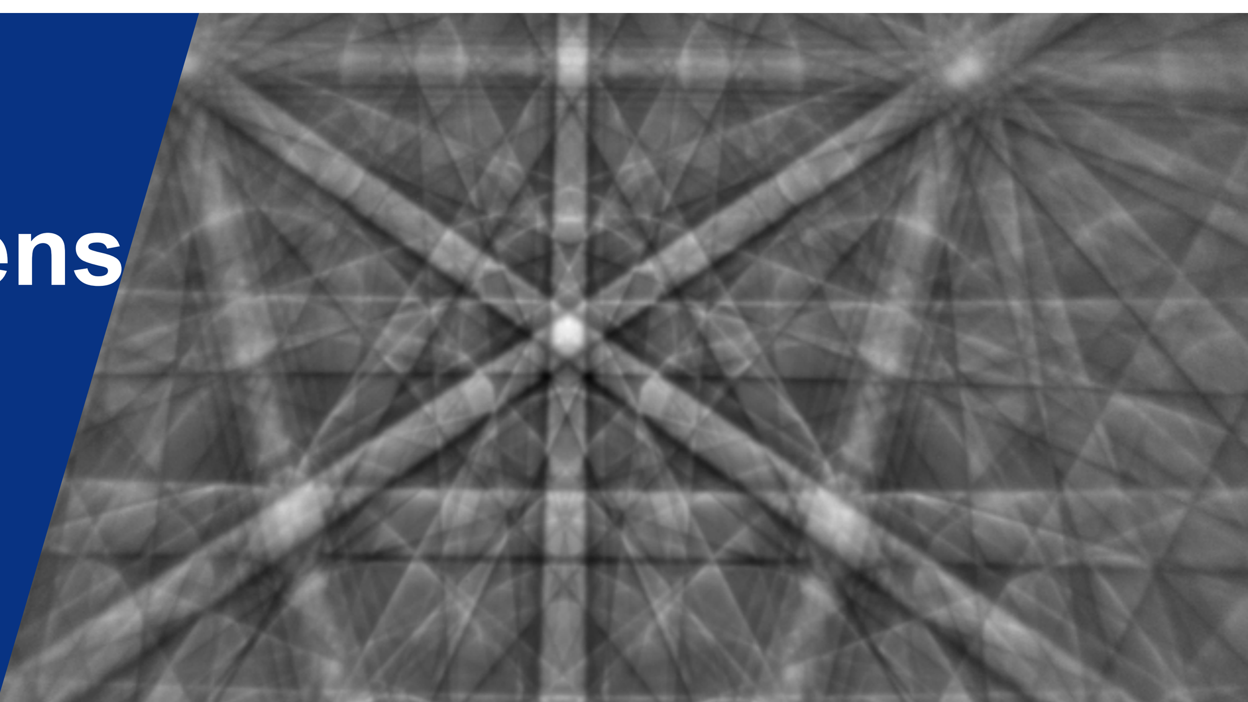

A masking technique to perform high accuracy diffraction experiments on FIB-machined specimens

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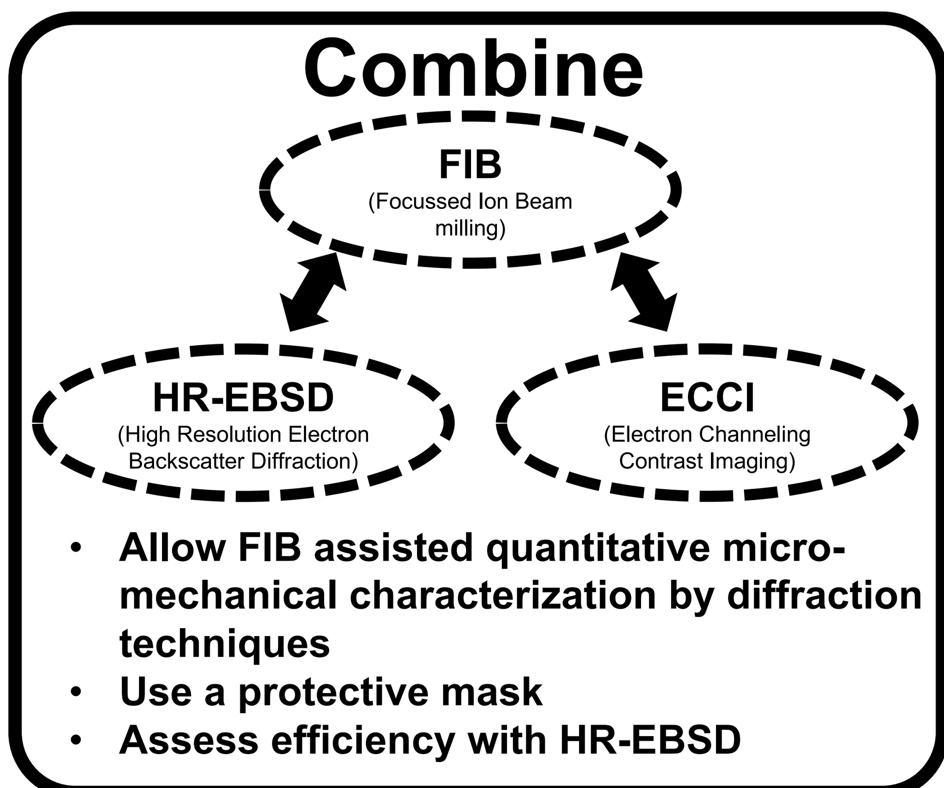
Goal

Combine



- Allow FIB assisted quantitative micro-mechanical characterization by diffraction techniques
- Use a protective mask
- Assess efficiency with HR-EBSD

Challenges

FIB damage effects

undamaged | damaged

TEM brighfield image of a copper film, showing undamaged and damaged area due to FIB exposure, reproduced from [Kiener et. al., 2007]

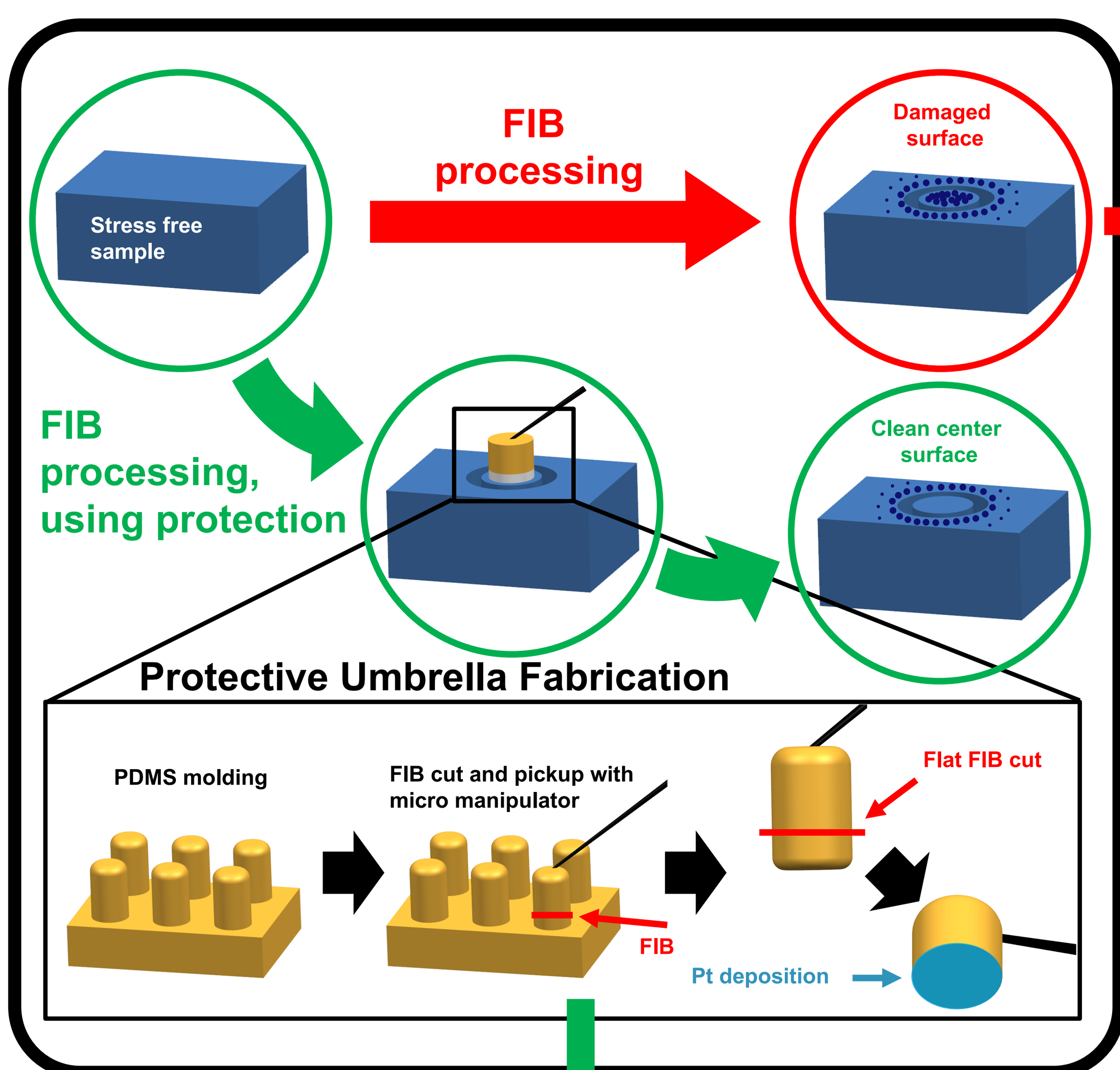
Ion implantation:
- Creates crystal defects by material-ion interactions
- Decreases crystallinity and EBSP quality
- Extra features on ECCI

Redeposition:
- Leaves extra amorphous layer in FIB areas
- Signal/noise ratio decrease in diffraction/channeling
- Diminution of contrast on EBSP and ECCI

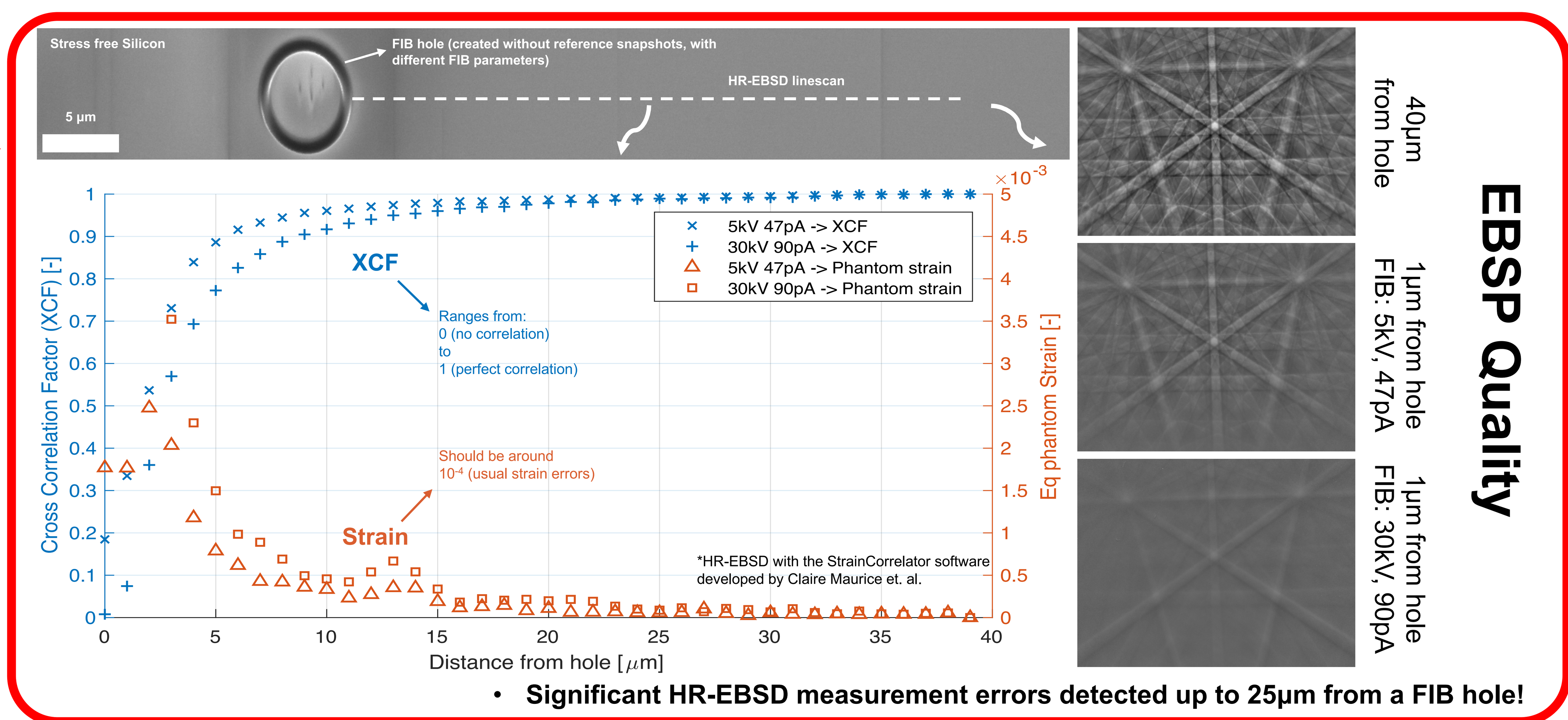
Surface topography by AFM near a FIB produced hole on High Speed Steel, reproduced from [Bhavsar et. al., 2012]

- Can a protective mask avoid the damage?

Method



Without protection



- Significant HR-EBSD measurement errors detected up to 25μm from a FIB hole!

With protection

Umbrella fabrication

1. Molded **soft** PDMS pillar, cut off with FIB
2. Rough umbrella block on Silicon surface
3. Inset: flat cutting of umbrella. Deposit layer of Pt
4. Final umbrella attached to micro manipulator

Umbrella assisted FIB & HR-EBSD (in situ)

1. HR-EBSD reference spots on Silicon substrate
2. Umbrella placed on Silicon surface at spot locations
3. FIB milling around umbrella
4. Protected surface after umbrella removal, new HR-EBSD spots taken

Correlate spots

HR-EBSD results

XCF

Strain

Cross Correlation Factor (XCF) [-] / Eq phantom Strain [-] / spot

- Using the umbrella mask, the protected surface retains a quality close to the original one!

Discussion

- Without protection, the damaging effect of FIB on surface quality is devastating for EBSD and ECCI. This is mainly caused by amorphous redeposition layers
- Good protection not trivial, optimized umbrella is necessary
- Protection not perfect yet, redeposition can still come in under the block

Conclusions

- Without protection, advanced diffraction techniques cannot be used near or on FIB machined specimens
- A soft rubber umbrella, with a flat Pt coated bottom is highly effective in protection
- The umbrella fabrication process allows freedom in size, materials and applications (e.g. protection of micro tensile bars)

EBSD 2017

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