Hydrofluoric Acid-Free Titanium Etching for Rare-Event Searches

P. Knights[1], I. Manthos[2], K. Nikolopoulos[1,2], G. Rogers[1,3], D. Spathara[1], P Walters[1]
[1]University of Birmingham, [2]University of Hamburg, [3]STFC Boulby Underground Laboratory

UK Research and Innovation
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Introduction

- Titanium a common detector material choice for rare event searches; high strength, machinability, low density
- Surface treatment required for direct use or prior to further treatment, e.g. alloying with electroformed copper [1, 2, 3]
- High chemical resistance: hydrofluoric acid generally required
- HF challenging chemical, even more so used underground
- An alternative: sulphuric acid, already used in underground laboratories [4], [5]. H_2SO_4 used for Ti etching in other fields [6]

H_2SO_4 Titanium Etching

- ⌀3.15 cm, 0.9 mm thick grade 1 Ti coupons used
- Sheet cast billet, pressed, then hot and cold rolled
- Coupons immersed in 99.8% analytical reagent grade ethanol, cleaning in an ultrasonic bath at 30°C for 30 minutes. Dried at 50°C for 1 h
- Weighed before and after etching
- Three coupons tested for each condition, studying effect of concentration and temperature

Figure 1: Set-up.

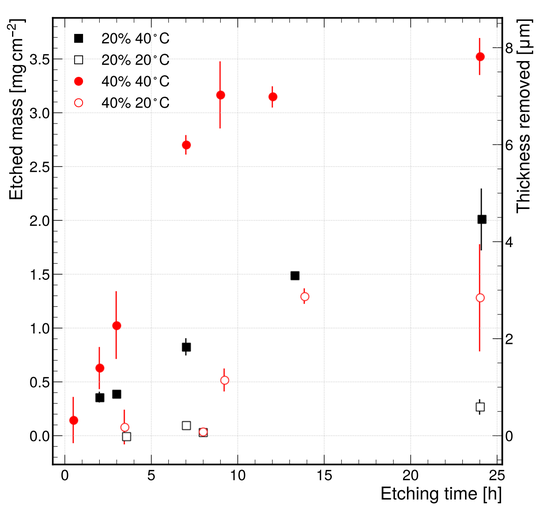

Figure 2: Mass change after etching.

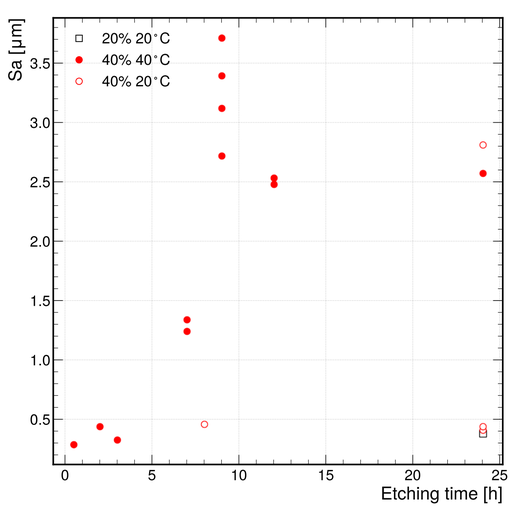

Figure 3: Surface roughness, *Sa*.

- Higher etching rate observed with higher temperature and concentration
- Similar trend seen in surface roughness

Surface Study: Electron Microscopy

- JEOL 7000F field emission gun–scanning electron microscope (SEM) in Secondary Electron Imaging (SEI) and Backscattered Electron Imaging (BEI) modes, for topology and composition investigations, respectively
- Composition from Energy-Dispersive X-ray (EDX) spectroscopy
- Debris seen from O and Fe prior to etching. Not observed after etching

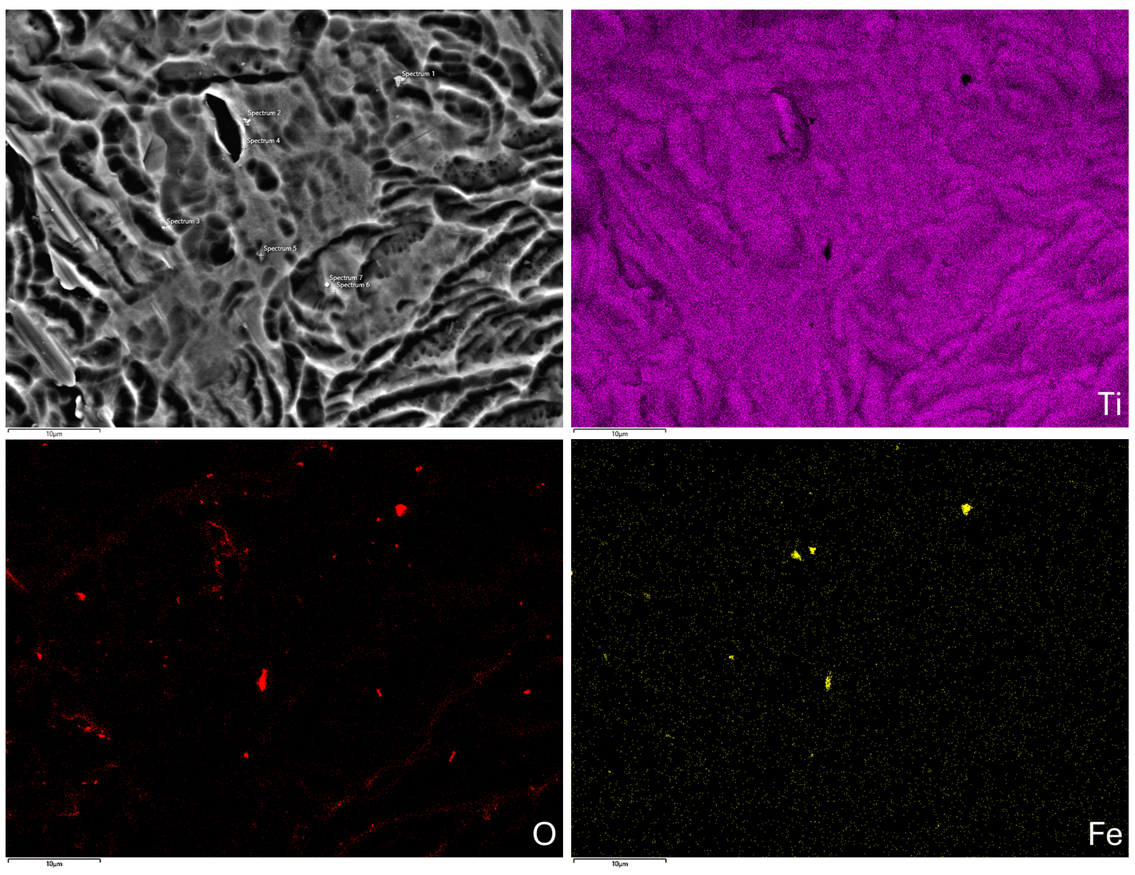

Figure 4: (Top left) BSE image of Ti surface prior to etching and (left to right in rows) the EDX maps of Ti, O, and Fe.

Surface Study: Optical Microscopy

- KEYENCE VHX-7000 digital optical microscope
- Study surface change before and after etching, including roughness

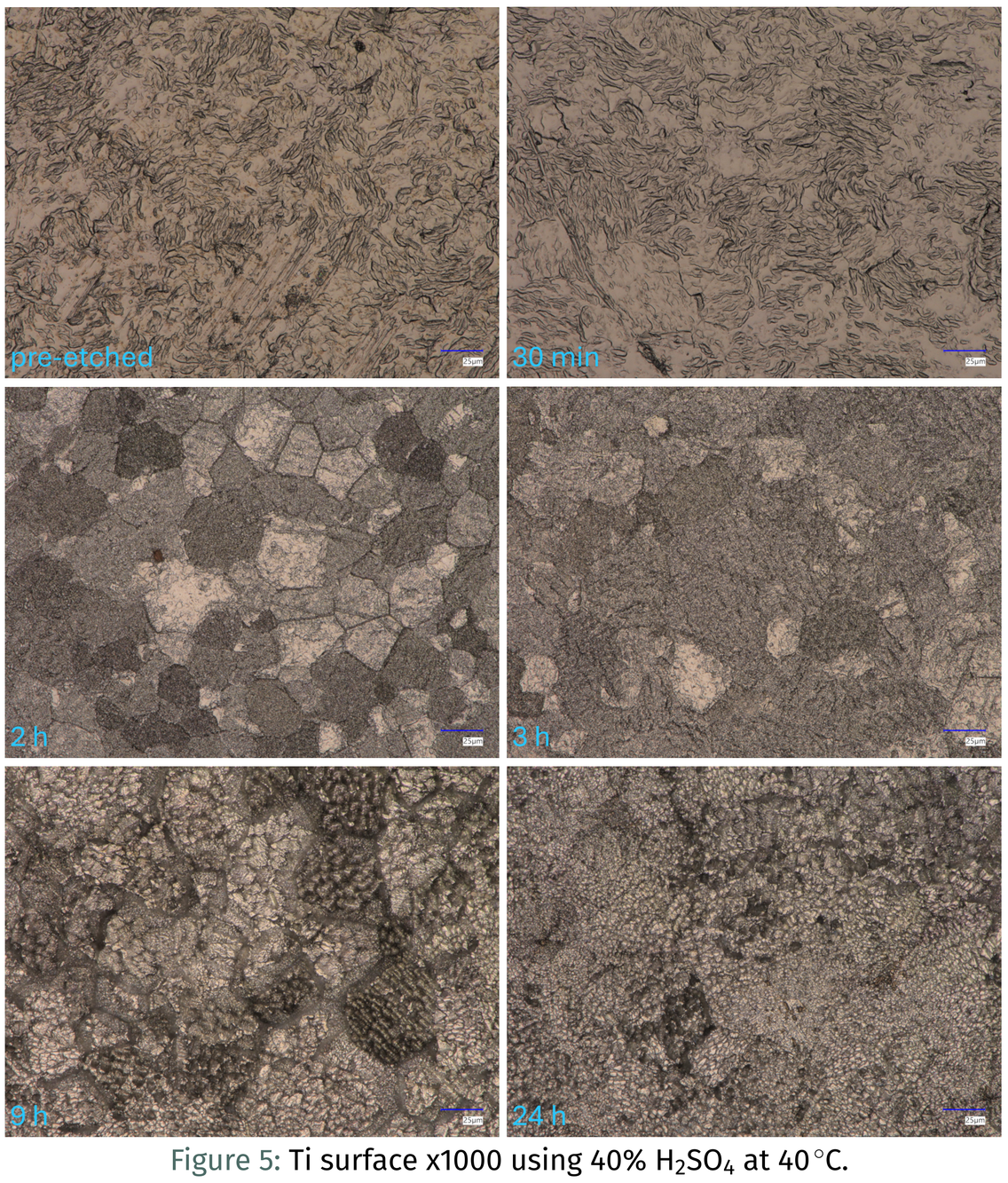

Figure 5: Ti surface x1000 using 40% H_2SO_4 at 40 °C.

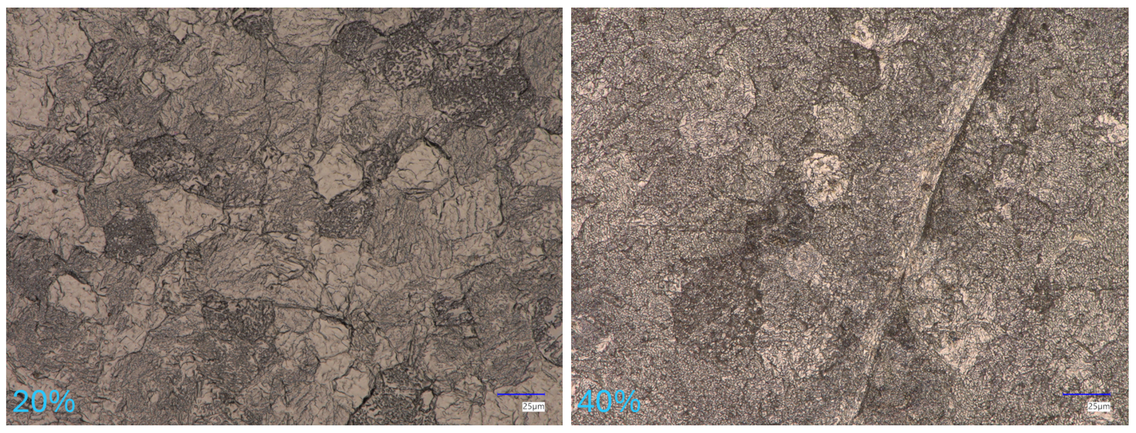

Figure 6: Ti surface x1000 after etching with H_2SO_4 after 24 h.

- Topology of the surface for 20% H_2SO_4 at 20 at 24 h matches that at 2 or 3 h for 40% at 40 °C. Agrees with etched mass measurements

Conclusion

- H_2SO_4 Ti etching for a range of concentrations and temperatures
- Demonstrated etching at room temperature
- Alternative to HF-based etching
- Benefits for safety, ease of use, known constituents, and disposal

Bibliography

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