# Water Erosion Resistant Surface Treatments

# Nitriding of Ti6Al4V

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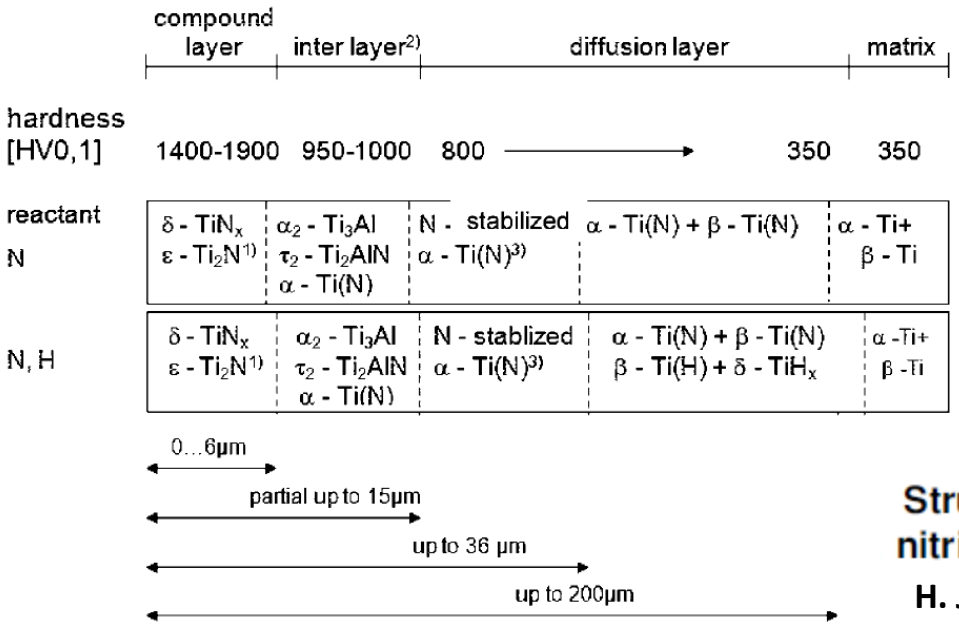
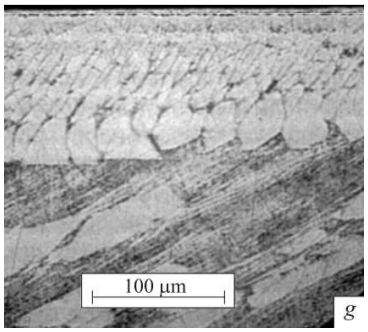
# Gas nitriding of Ti6Al4V

- ✓ **Appropriate thermo-chemical treatment for the Ti alloys in term of improving wear and erosion properties**

- ✓ **Including three layers:**

**Compound layer, inter layer, diffusion layer**



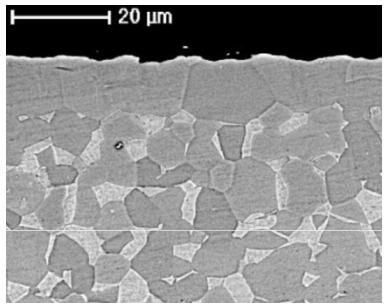




Structure of gas and plasma nitrided cases of $(\alpha+\beta)$ alloy

**H. J. Spies, 2010**

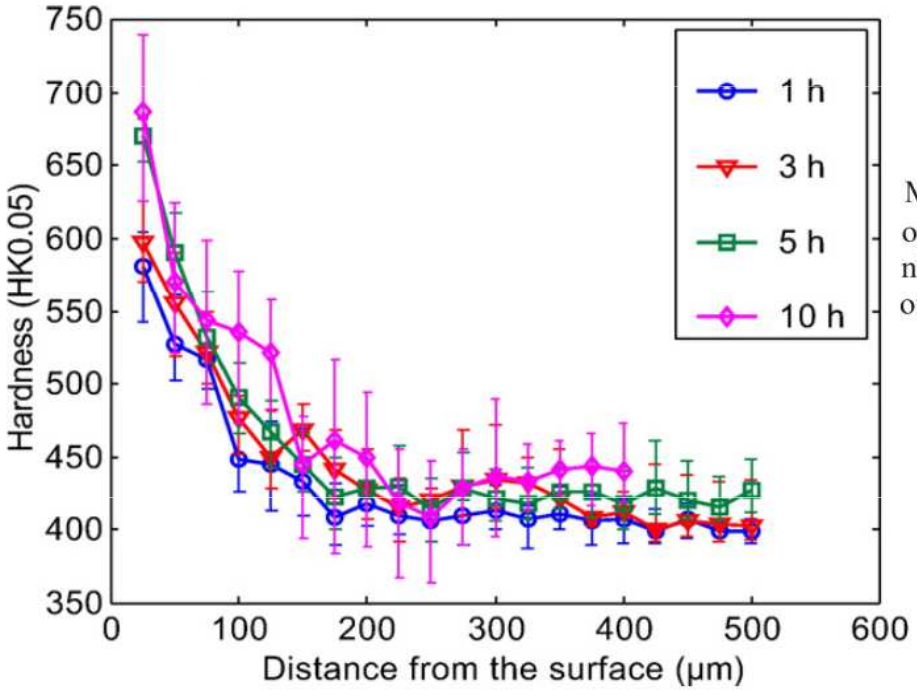
**Gas nitrided Ti6Al4V**

**F. ERNST, 2005**



# Gas nitriding of Ti6Al4V

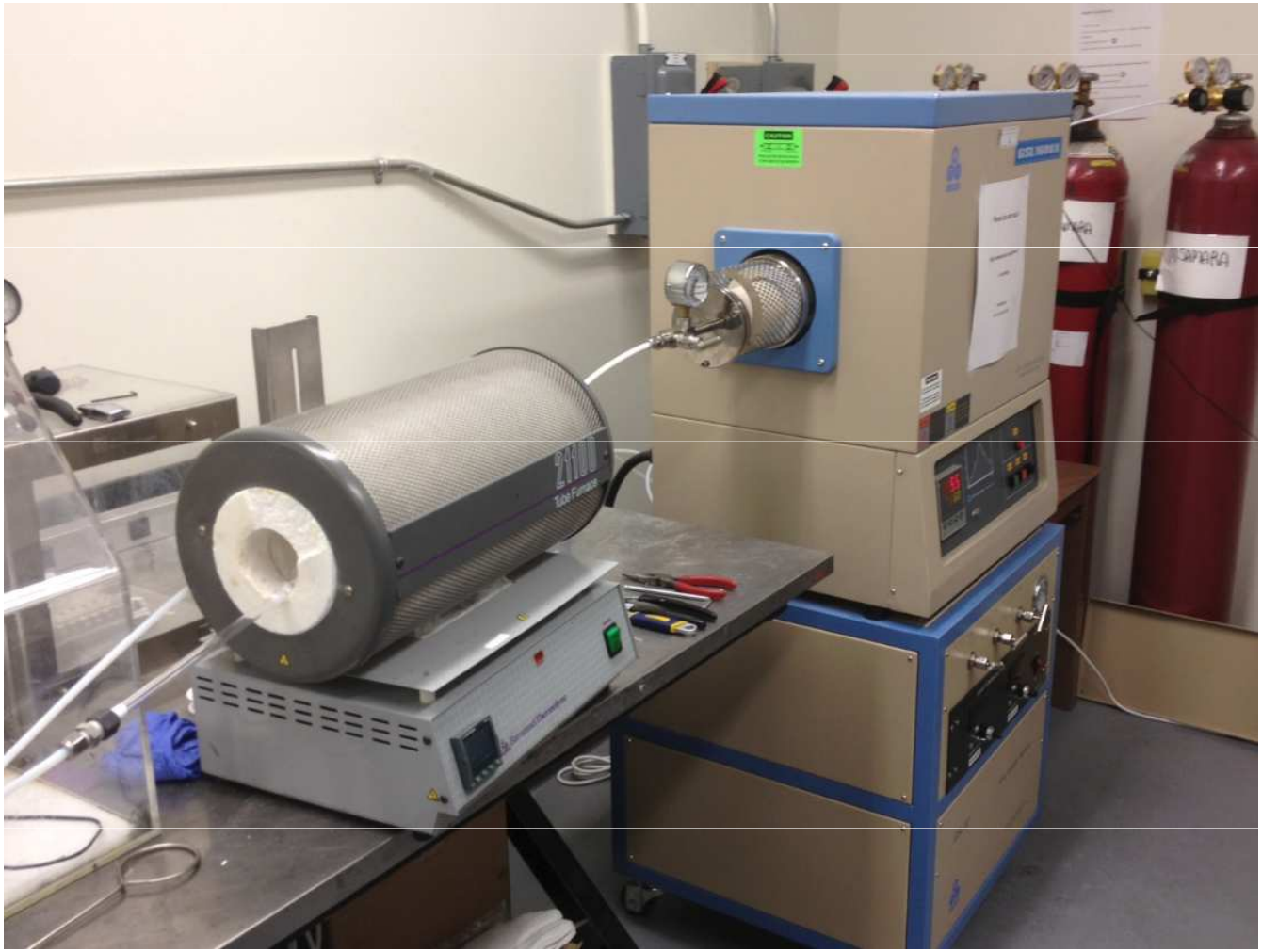
- ✓ **Thin, hard and multilayer coatings (compound and inter layers) seemed promising for improving WDE**
- ✓ **Thick and tough diffusion layer assumed as another advantage of nitriding for improving WDE**




Microhardness profiles of Ti–6Al–4V alloy after nitriding for different periods of time at 950 °C.

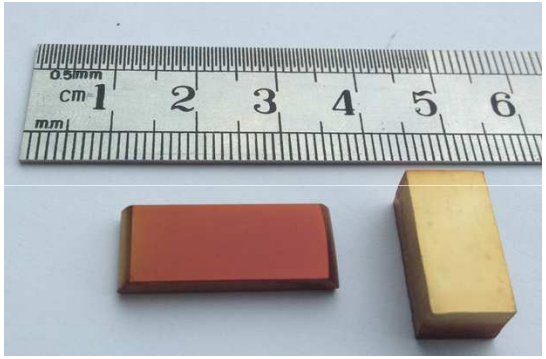
**Titanium alloys after surface gas nitriding, A. Zhecheva, 2006**

# Nitriding system



# Gas nitriding of Ti6Al4V at Concordia University

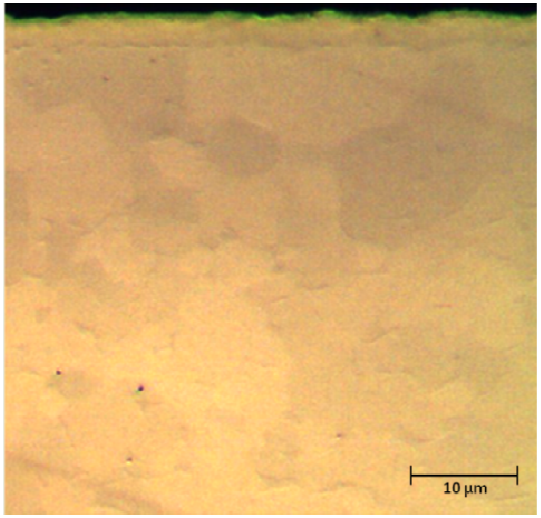
- Stabilizing the nitriding system in term of removing undesired oxygen and repeatability was time consuming process, but it has been done.
- Process parameters investigation for nitriding experiments has been planned as the following:

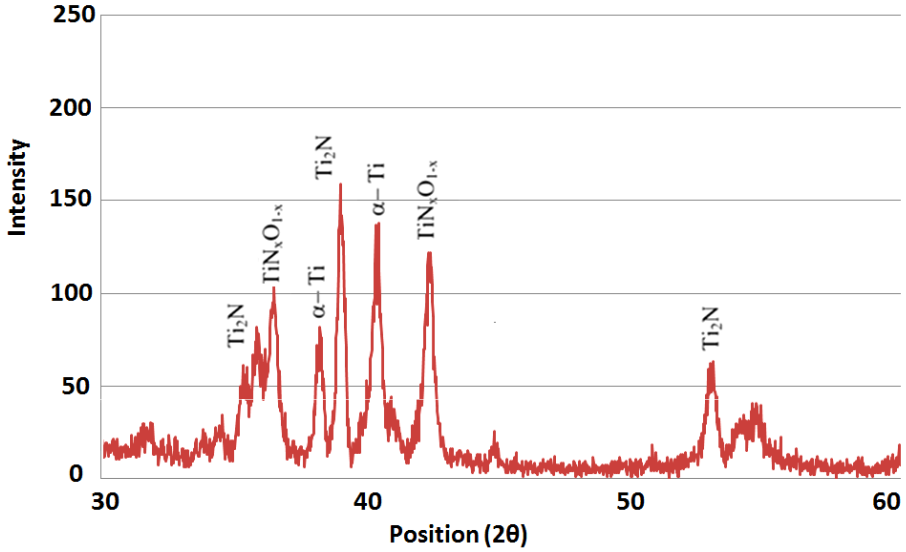


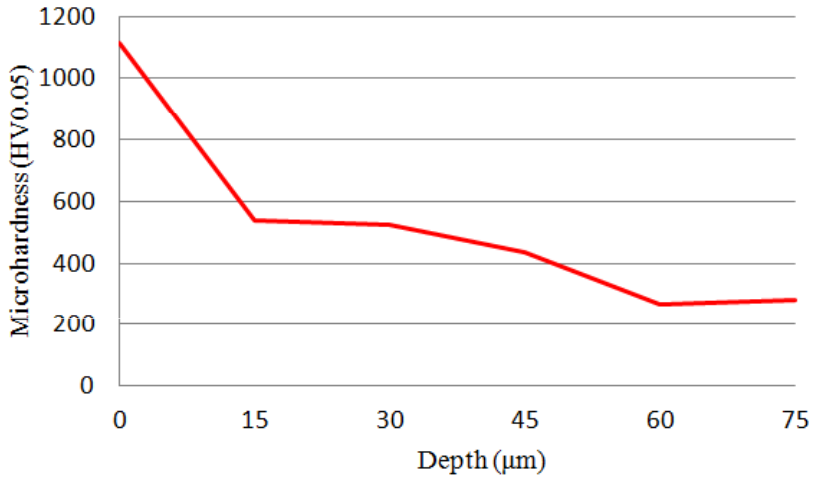

| | Temperature (°C) | Time (h) | $N_2$ flow (SCCM) |
|---|---|---|---|
| 1 | 1050 | 10 | 25 |
| 2 | 1050 | 2 | 100 |
| 3 | 900 | 2 | 25 |
| 4 | 1050 | 10 | 100 |
| 5 | 900 | 10 | 25 |
| 6 | 1050 | 2 | 25 |
| 7 | 900 | 10 | 100 |
| 8 | 900 | 2 | 100 |

# Characterization of nitrided Ti6Al4V

- ✓ Confirming formation of nitrided phases by XRD
- ✓ Preparing the cross section micrograph of nitrided Ti6Al4V to measure investigate different layers
- ✓ Measuring the surface hardness and hardness profile in the depth of sample



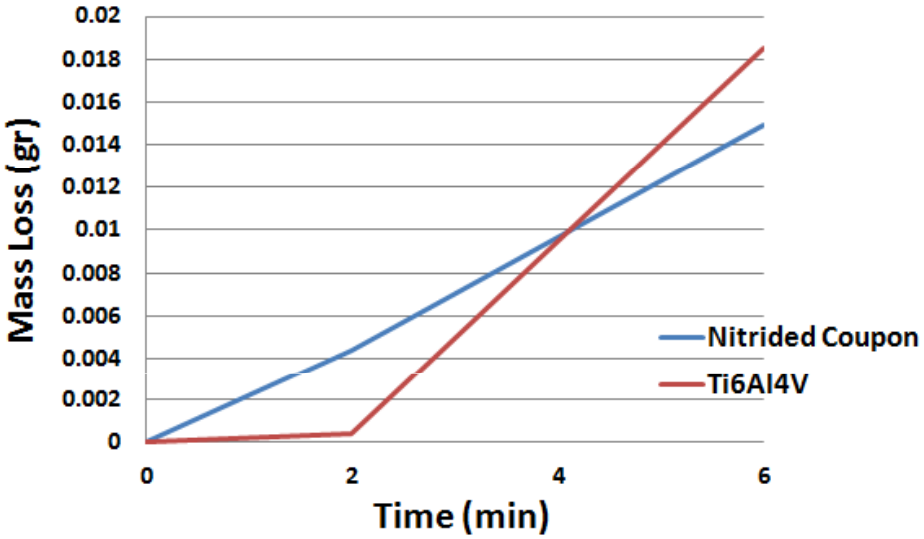



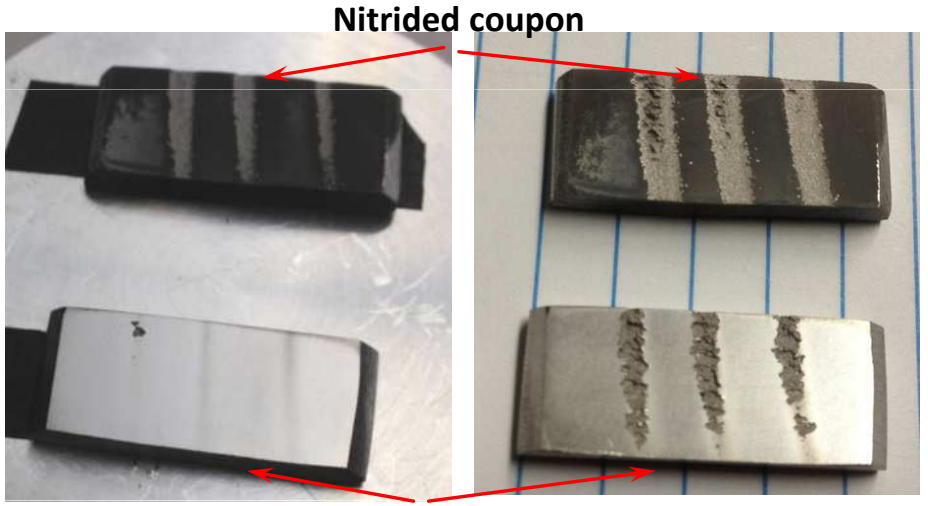



# WDE of nitrided Ti6Al4V Coupons

- ✓ Impinging speed= 14000 rpm (340 m/s)
- ✓ Time= 2 min, 4 min
- ✓ Droplet size 400-600 µm
- ✓ Three streams
- ✓ Distance from nuzzle to sample around 45 mm
- ✓ Flow 0.06 L/min

Ti6Al4V Nitrided at 1000 °C for 9 hours, initial samples with some contaminations on the surface



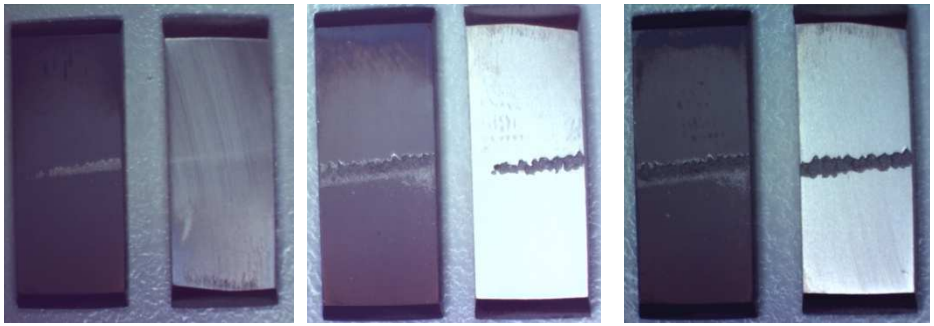




After 2 min erosion

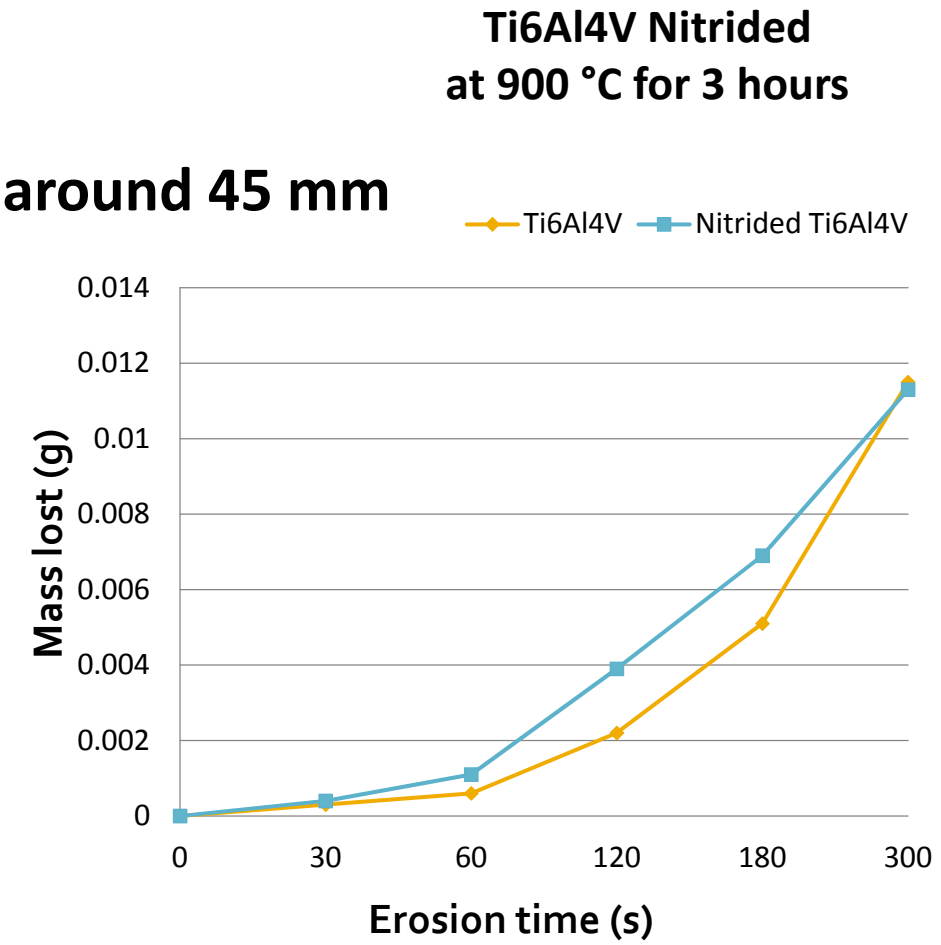
After 6 min erosion

# WDE of nitrided Ti6Al4V Coupons

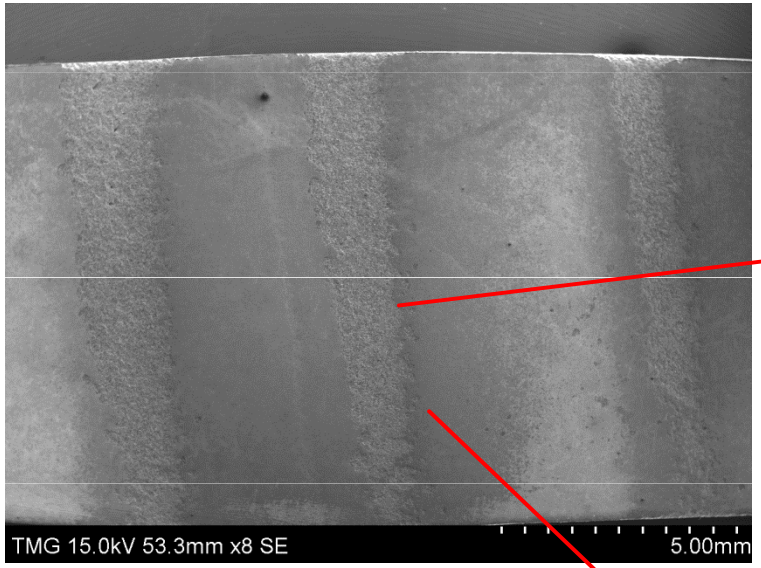
- Impinging speed= 14000 rpm (340 m/s)
- Time= 30 s, 30 s, 60 s, 60 s, 120 s
- Droplet size 400-600 µm
- One stream
- Distance from nuzzle to sample around 45 mm
- Flow 0.04 L/min

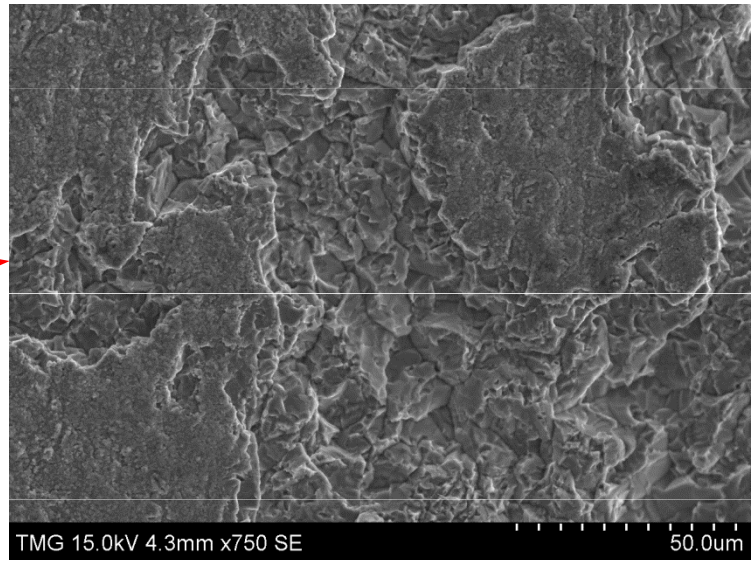


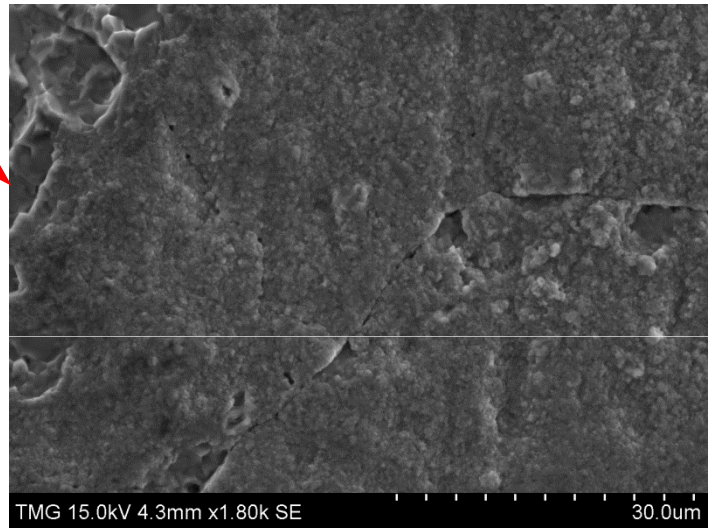
After 1 min  After 3 min  After 5 min



# SEM micrographs of eroded nitrided coupons

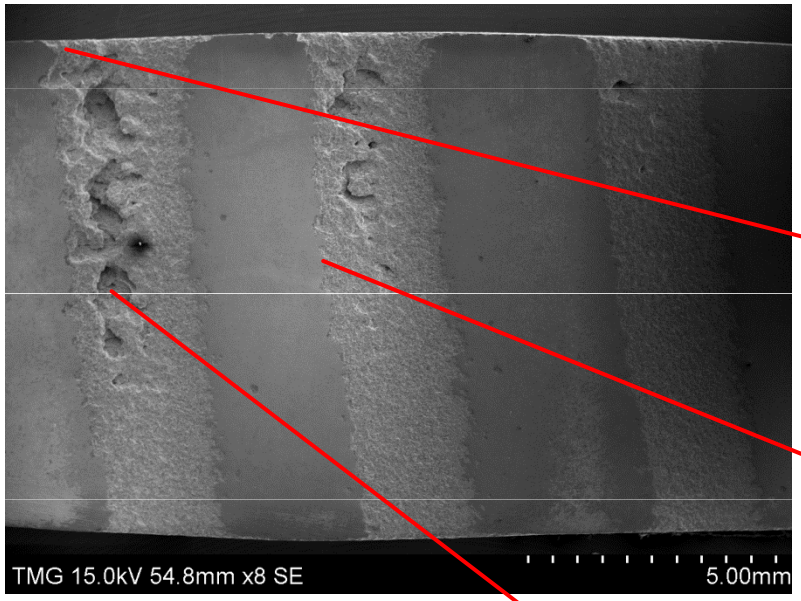


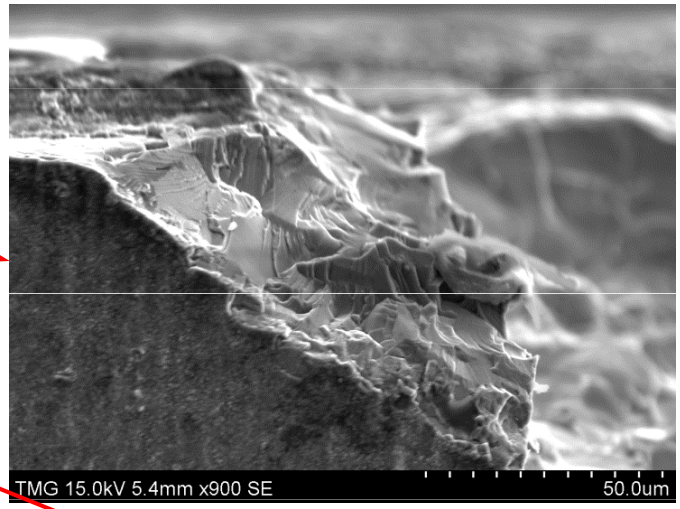



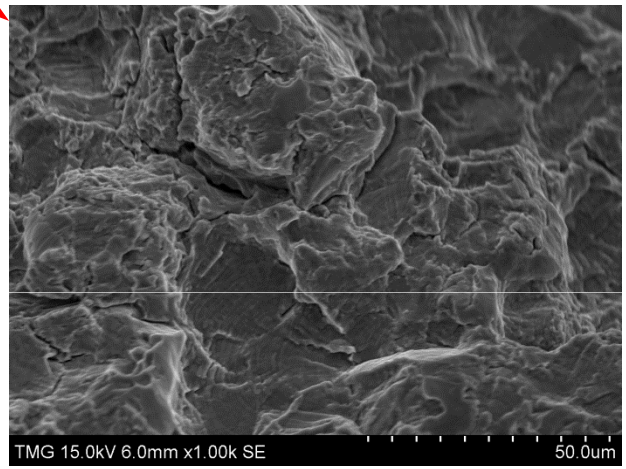



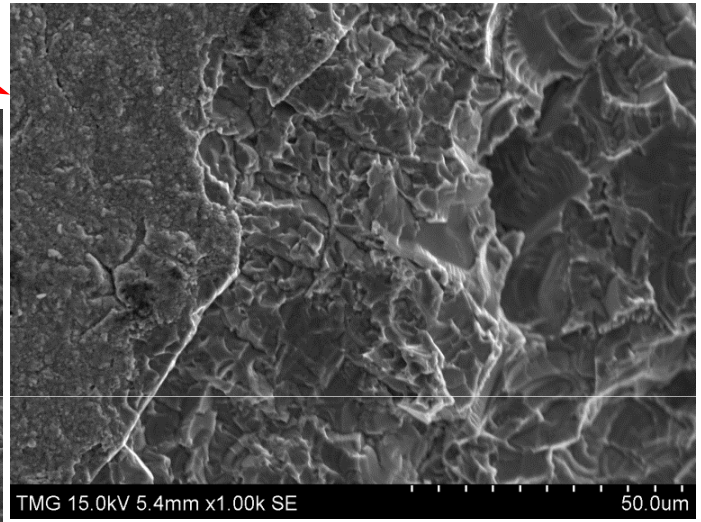

- ✓ After 2 min erosion
- ✓ Detachment of compound layer
- ✓ Many cracks on compound layer close to eroded tracks

# SEM micrographs of eroded nitrided coupons




- ✓ **After 6 min erosion**
- ✓ **Detachment of compound layer and erosion of diffusion layer (substrate)**

# Conclusion and future works

## Conclusions

- ✓ According to the initial erosion result, it seems the compound layers are significantly vulnerable to WDE because of their adhesion strength and brittleness.
- ✓ The diffusion layer showed promising results because it is not brittle and there is no interface.

## Future works

- ✓ Adjusting nitriding process parameters to have better conditions for diffusion layer
- ✓ Coating the TiN layer by CAPVD on the nitrided Ti6AlV in order to have better adhesion strength for top layers

Thank You