
Interlayer Assisted Molybdenum Coatings on Steel through LISI™

Deepak Rajput, Kathleen Lansford, Lino Costa, William Hofmeister

Contact: drajput@utsi.edu



www.utsi.edu

Center for Laser Applications

*University of Tennessee
Space Institute*

*411 B. H. Goethert Parkway
Tullahoma, TN 37388*

PHYS 593 Independent Study: Physics Seminar



Properties of Mo

- High melting temperature ($\sim 2623^{\circ}\text{C}$)
- High hardness (~ 1530 VHN)
- No reaction with water and oxygen at RT
- Good weldability
- Good ductility and fabricability
- Good machinability
- Good thermal conductivity
- Low coefficient of thermal expansion

Why Mo on Steel ?

Improves hardness

Improves corrosion resistance

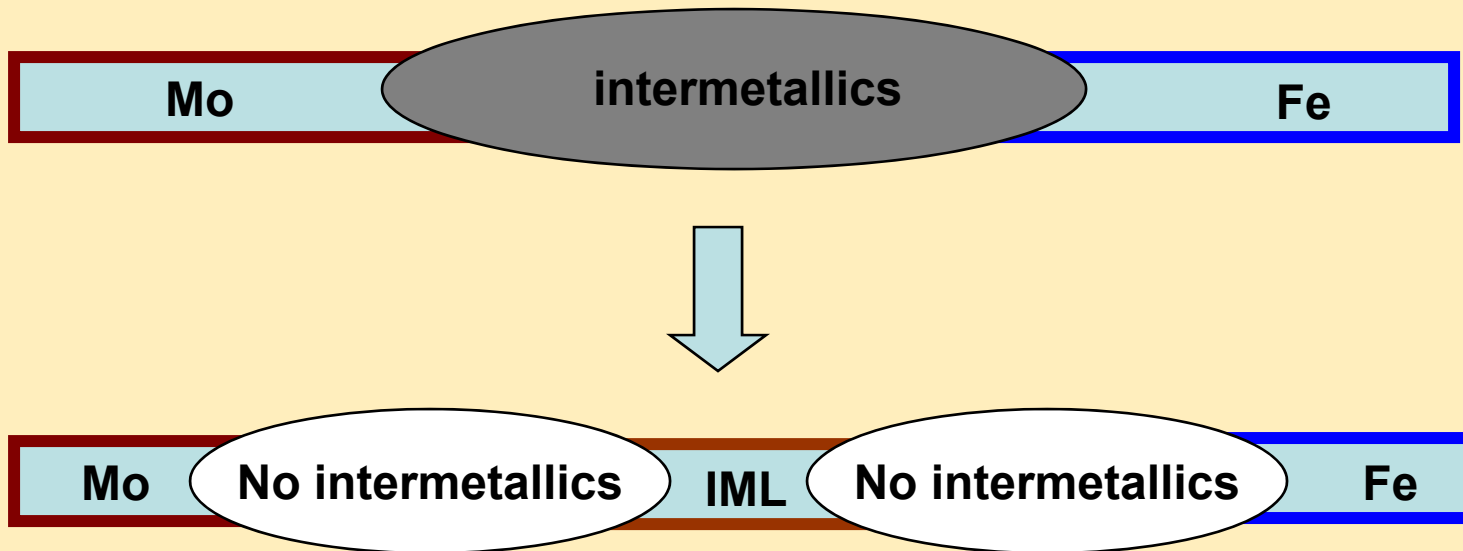
Improves high temperature strength

Direct LD of Mo on Steel: Problems

- Melting point of Mo ($\sim 2623^{\circ}\text{C}$) is much higher than that of steel ($\sim 1530^{\circ}\text{C}$).
- Mo and Fe form high and low temperature intermetallics.

Solution

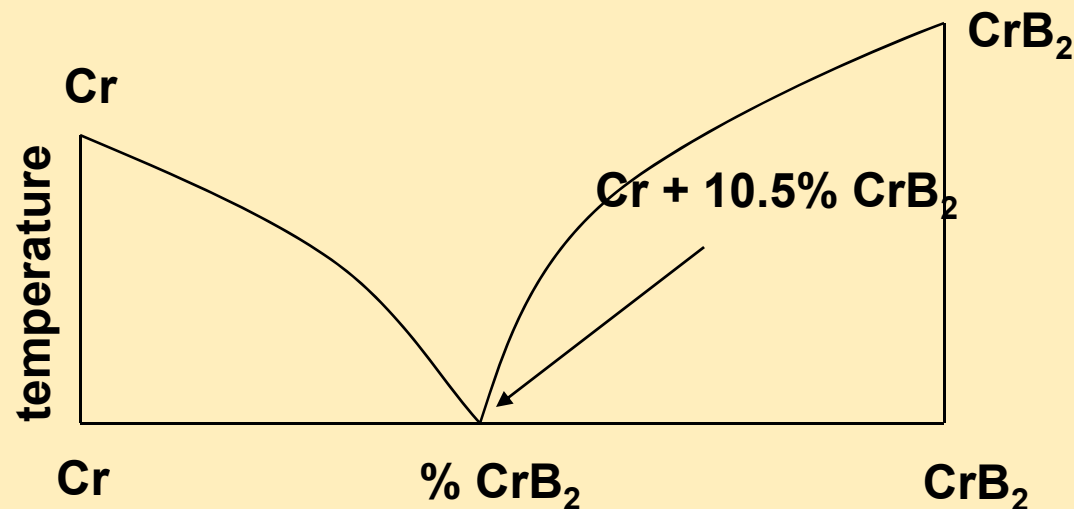
- Intermediate layers of materials that don't form intermetallics with Steel and Mo



Phase diagrams show that Cr, V and Nb are the best intermediate layers (IML)

Chemistry & Stoichiometry

- $\text{Cr}^* = \text{Cr} + \text{CrB}_2$ eutectic mixture (9:1) - **IML**
- $\text{Mo}^* = \text{Mo} + \text{MoB}$ eutectic mixture (7:3) - **ML**
- B gives additional hardness



Eutectic: System that melts at a temperature much lower than its constituents
Cr-B and Mo-B form eutectic systems

Process: LISI™

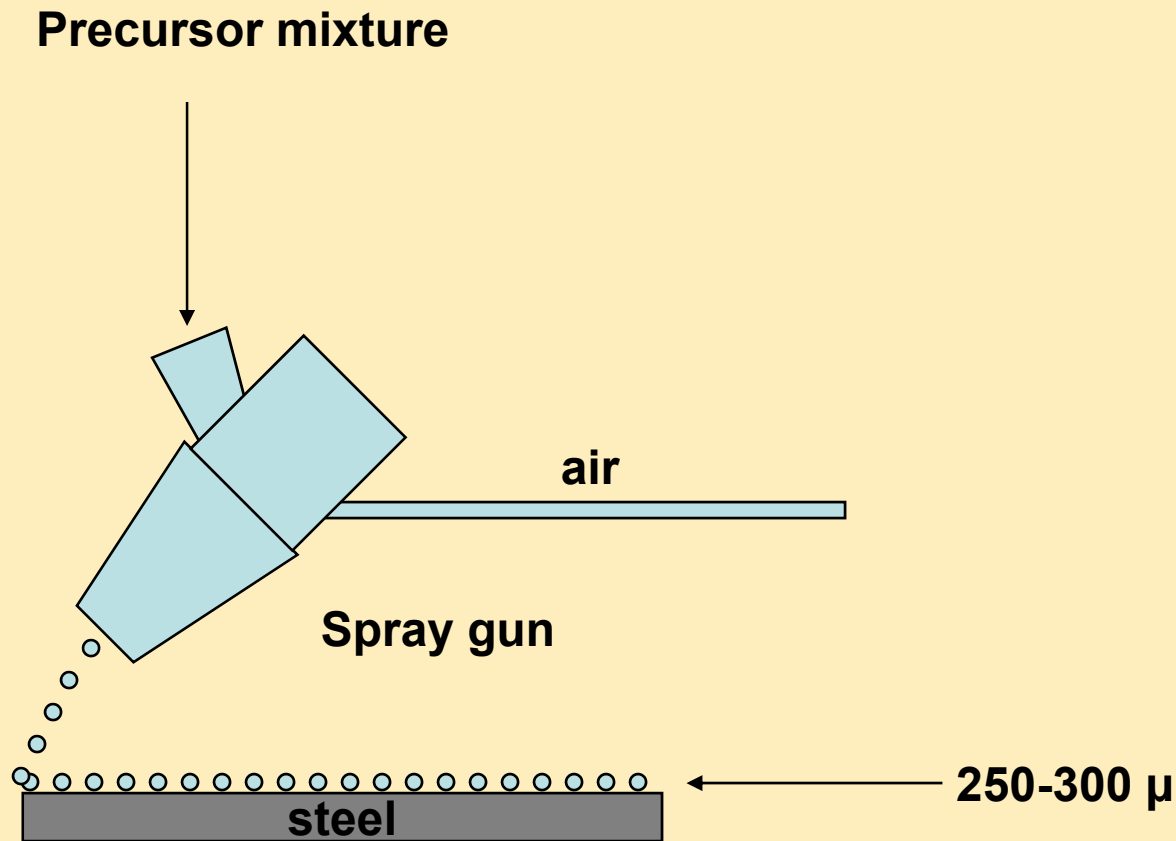
- Laser Induced Surface Improvement
- Uses pre-placed powder (precursor)
- Precursor = Metal powders + Binder
- Dry for few hours
- Laser process

Intermediate layer = Cr + 10.5%CrB₂ + 50% binder

Main layer = Mo + 30% MoB + 85% binder

Precursor Deposition

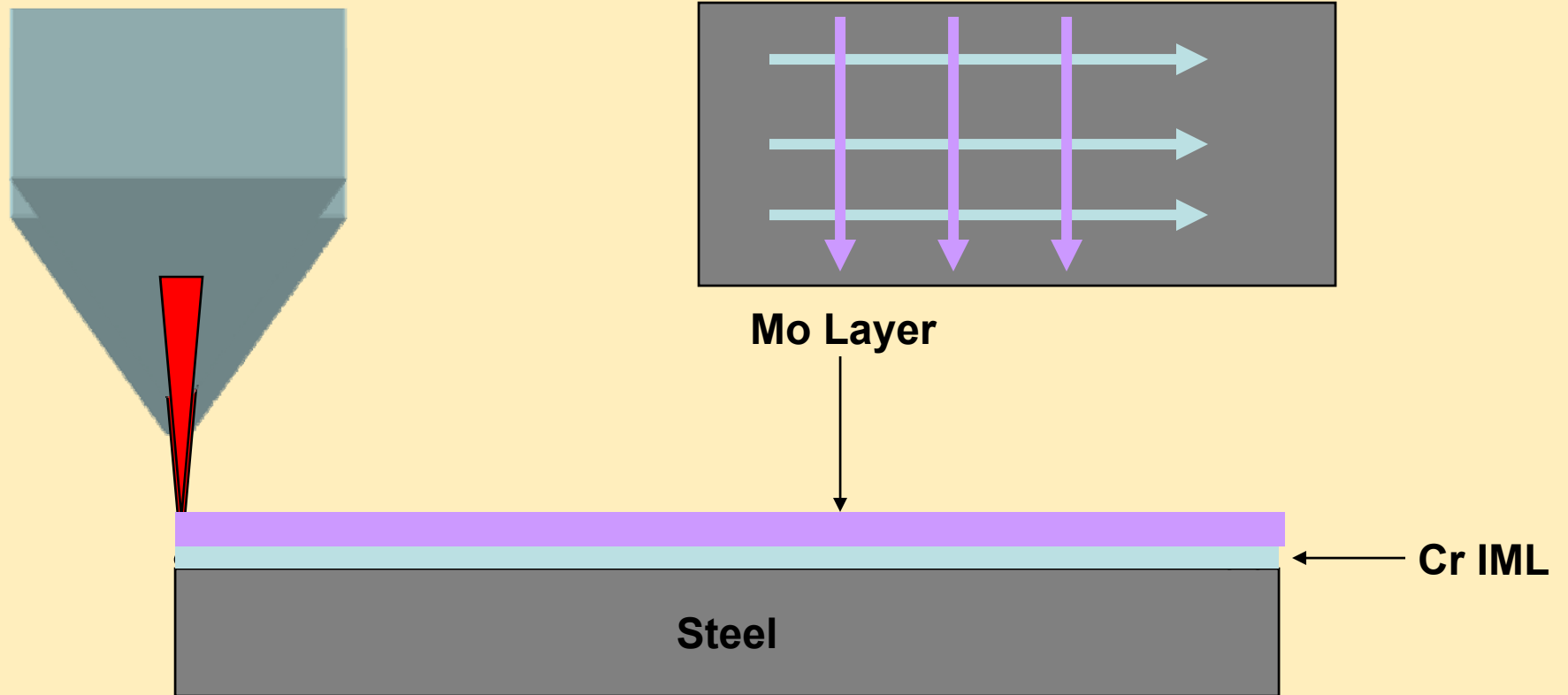
Precursor mixture = Metal Powders + Binder



Laser Deposition

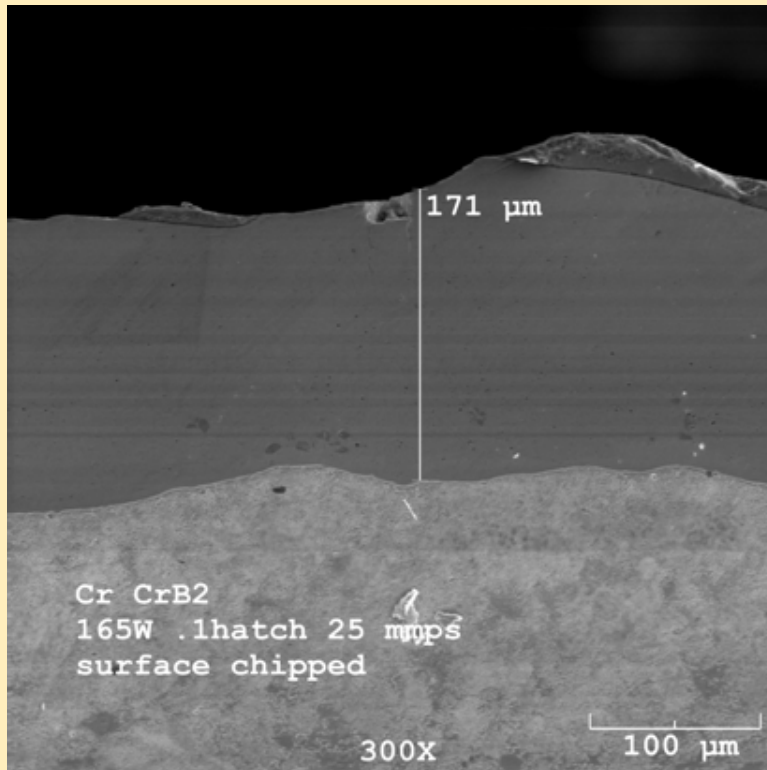
Cr* = 165W, 25mm/s, Hatch 0.1mm @ 355nm

Mo* = 180W, 25mm/s, Hatch 0.1mm @355nm

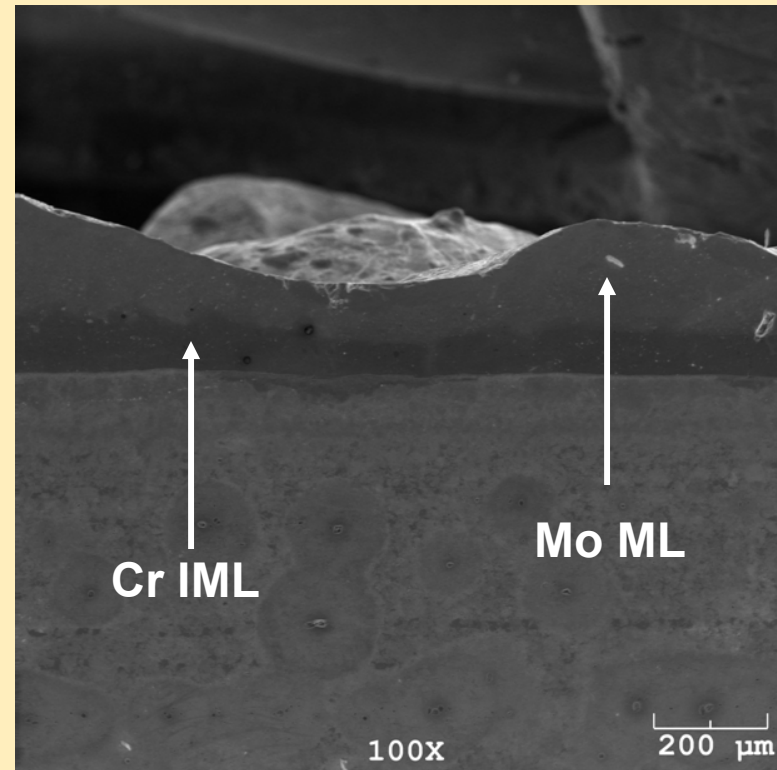


Coatings

SEM pictures



Cr* Intermediate Layer



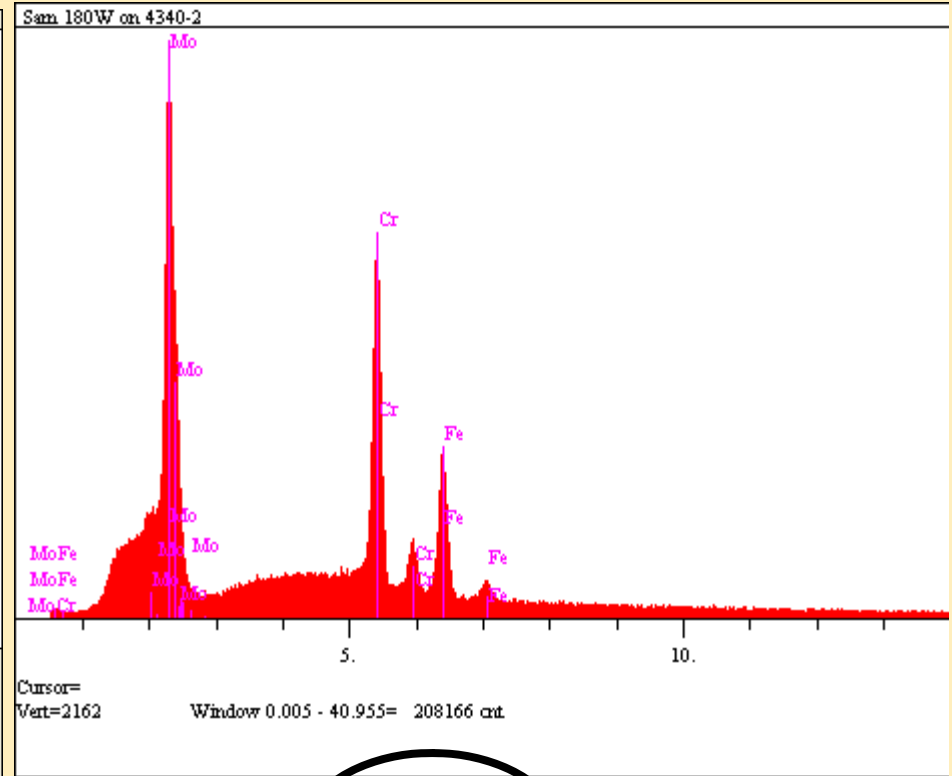
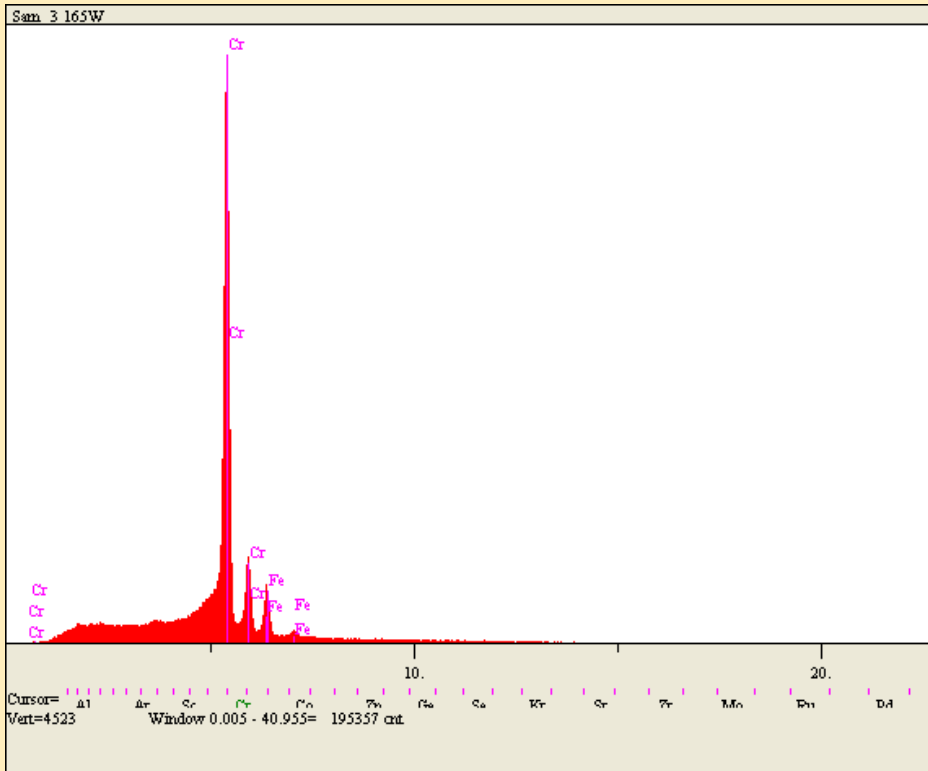
Mo* Main Layer

Steel Substrate: 4340 Alloy Steel

EDS Analysis

Cr IML

Mo IML



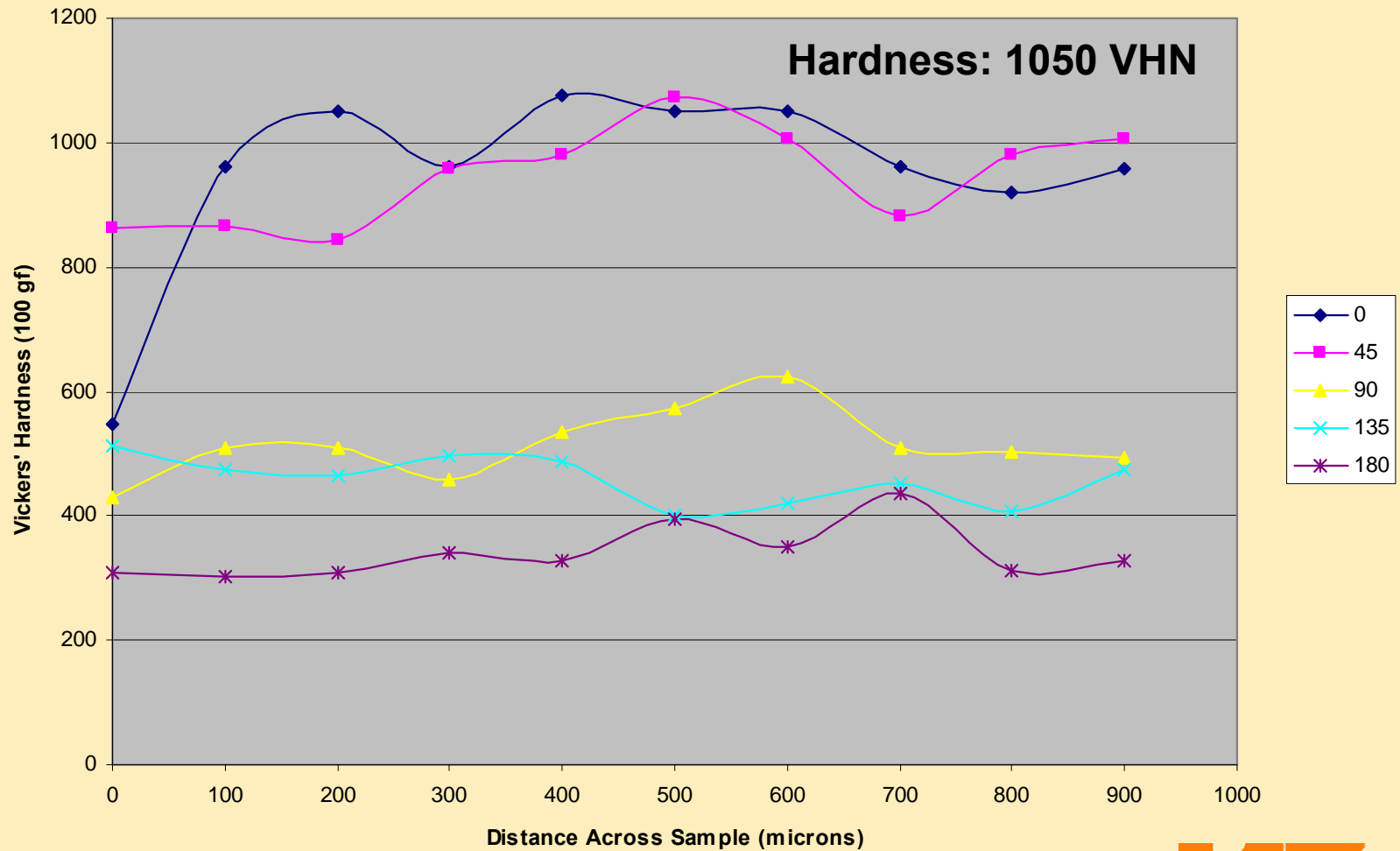
Fe: 11.9 %
Cr: 88.1 %

Fe: 11.5 %
Cr: 21 %
Mo: 67.5 %

We are working !

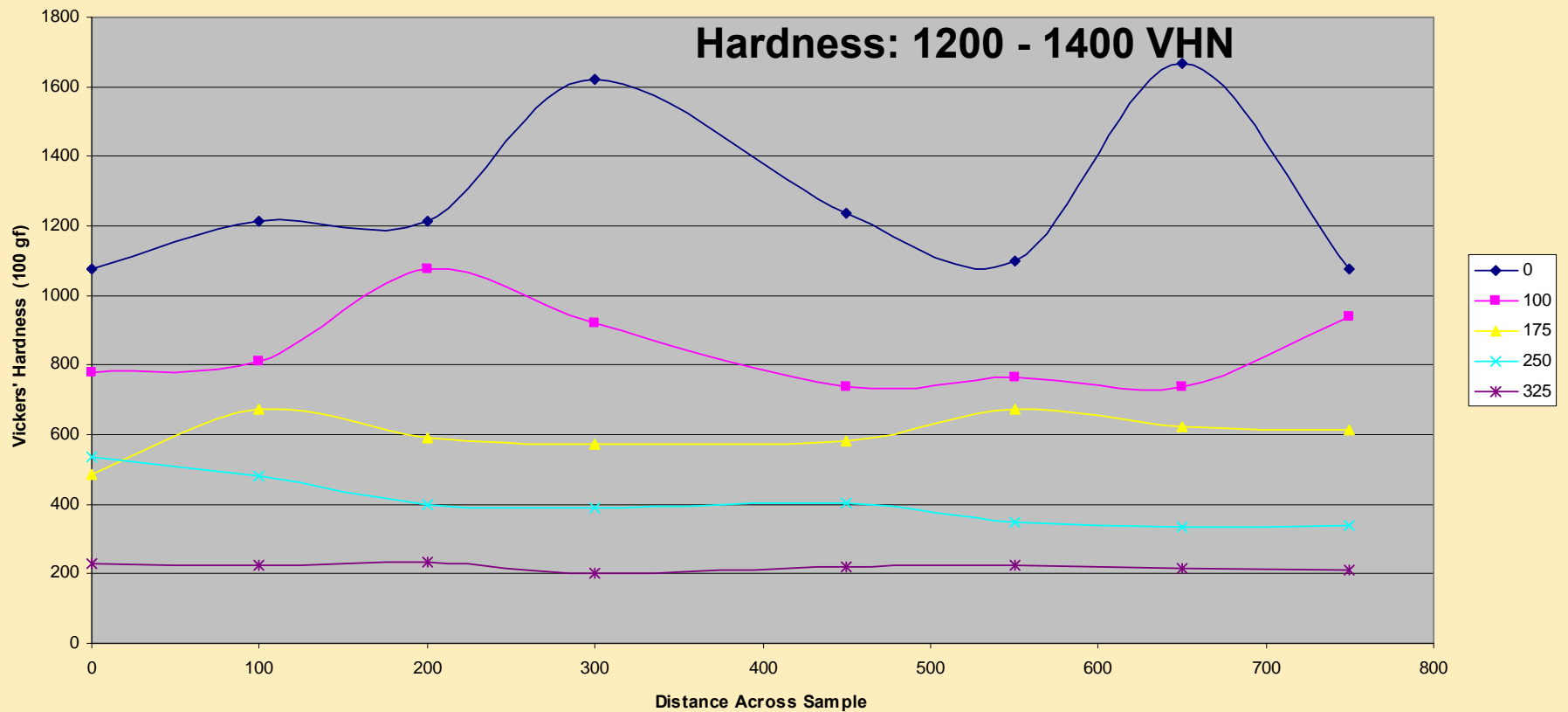
Microhardness: Cr* IML

Cr* on 4340 Steel

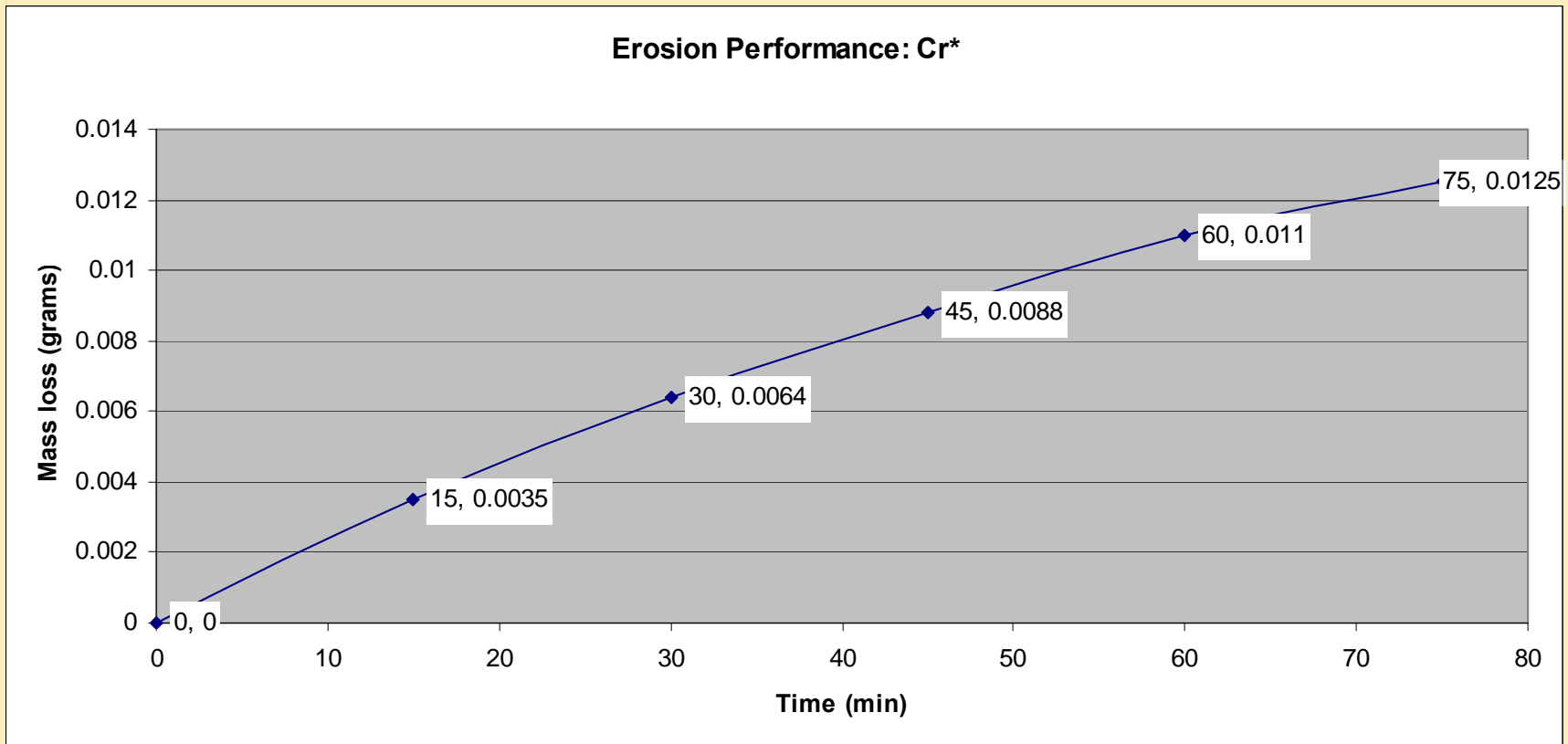


Microhardness: Mo* ML

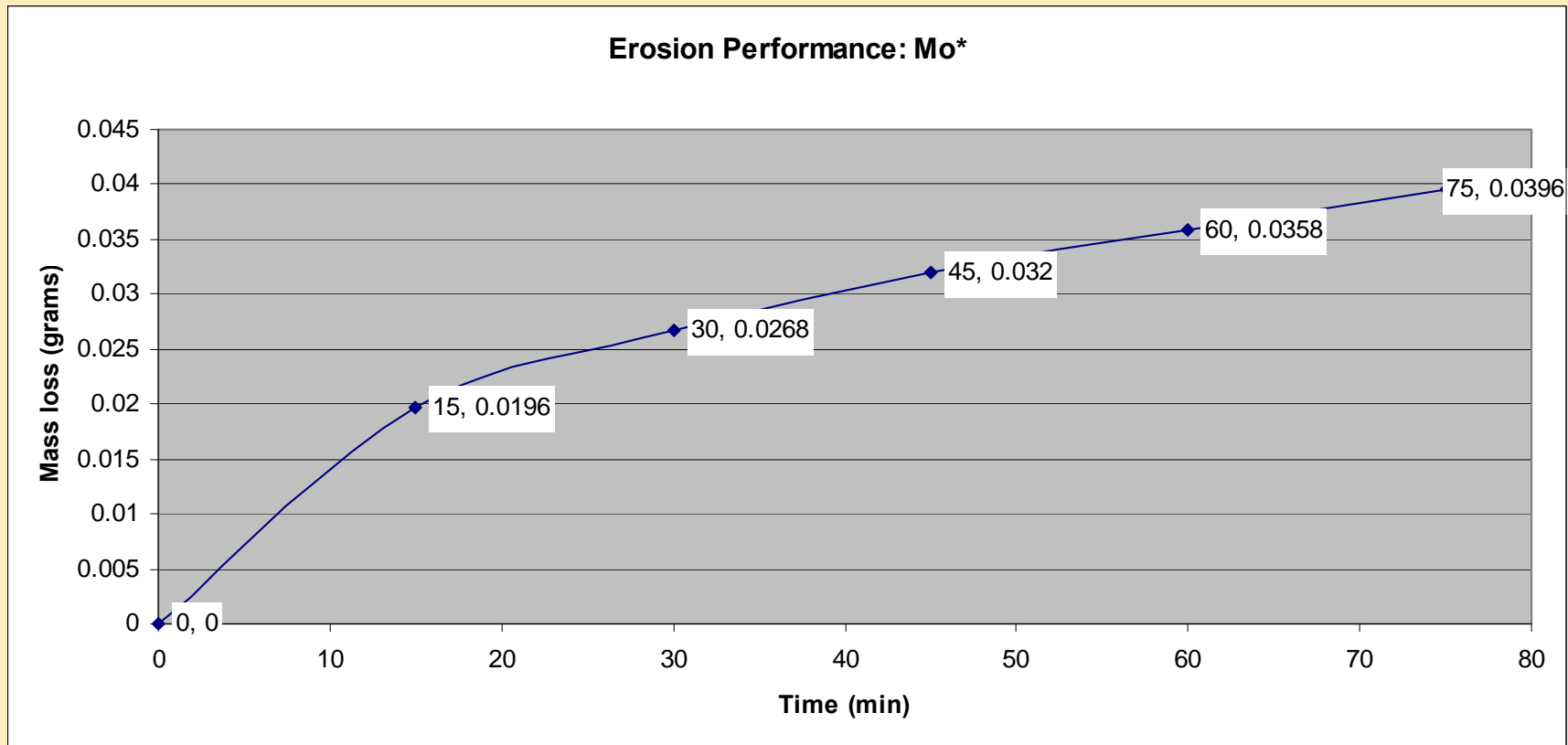
Mo* on Cr* on 4340 Steel



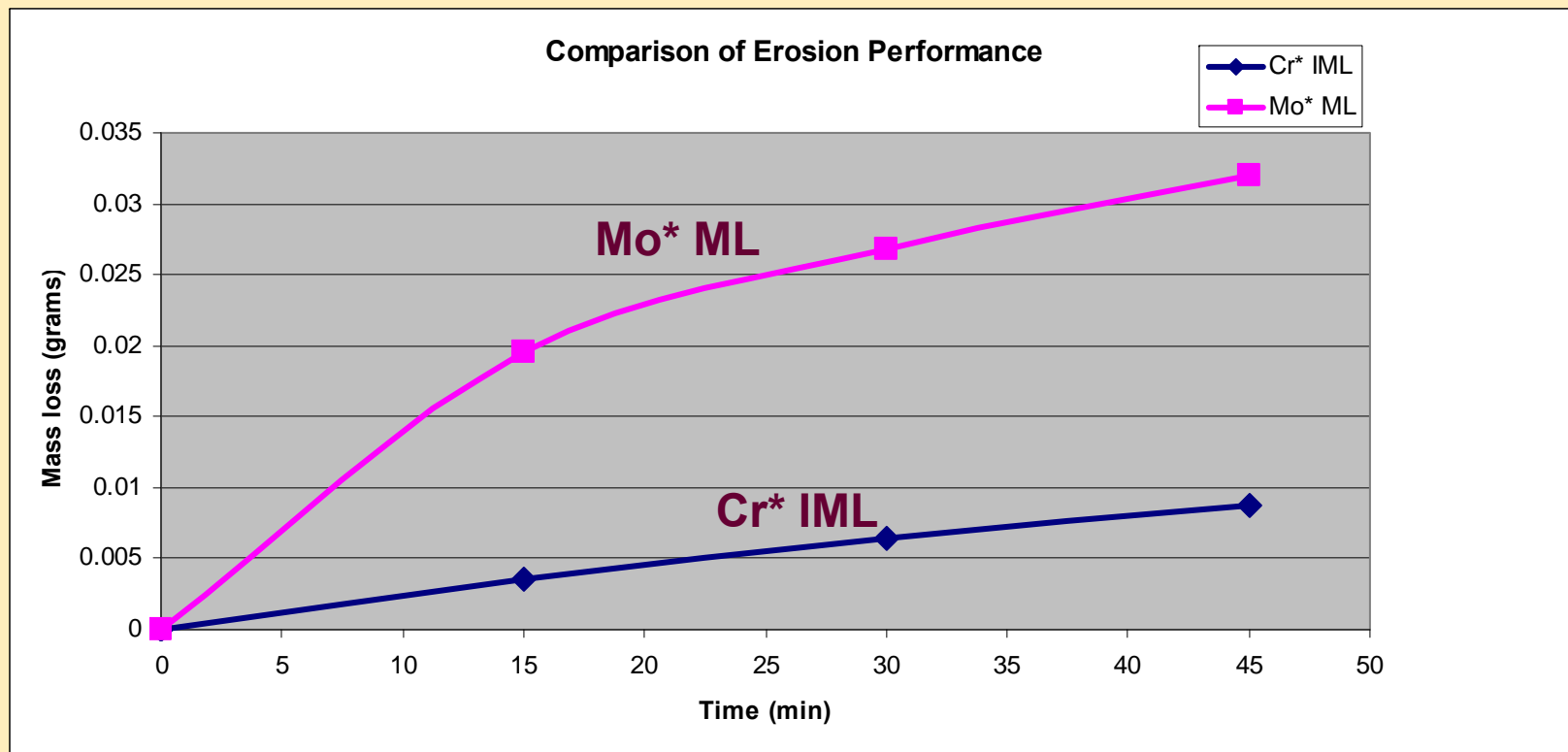
Erosion: Cr* IML



Erosion: Mo* ML



Erosion: Comparison



Summary

- A thick Mo coating
- Dilution within permissible range
- Very hard ML and IML
- Erosion of the ML is worse than the IML

Overall: Good Mo coating!
(grade: **B**)

No conclusion: We are still working !!

Further investigation

- XRD studies for phase determination
- Wear studies
- Fine tuning of process parameters to further reduce dilution and continuity of the layers

Questions

Thank You

(I appreciate your patience)