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# Interlayer Assisted Molybdenum Coatings on Steel through LISI™

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**PHYS 593 Independent Study: Physics Seminar**



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# Properties of Mo

- High melting temperature ( $\sim 2623^{\circ}\text{C}$ )
- High hardness ( $\sim 1530$  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

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# Why Mo on Steel ?

Improves hardness

Improves corrosion resistance

Improves high temperature strength

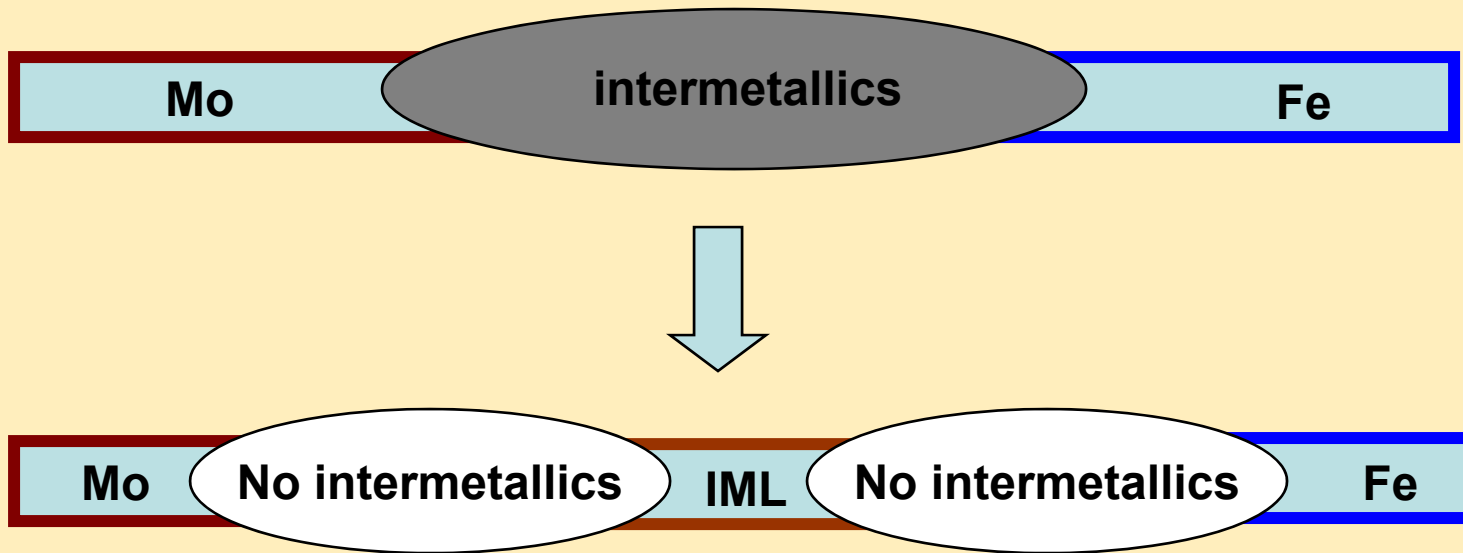
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# Direct LD of Mo on Steel: Problems

- 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

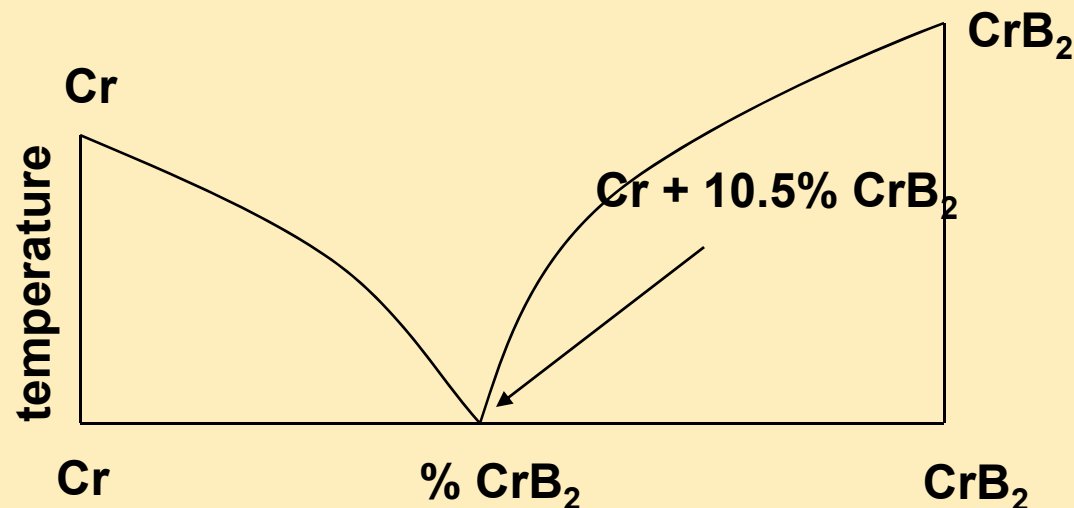
- Intermediate layers of materials that don't form intermetallics with Steel and Mo



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**

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# Process: LISI™

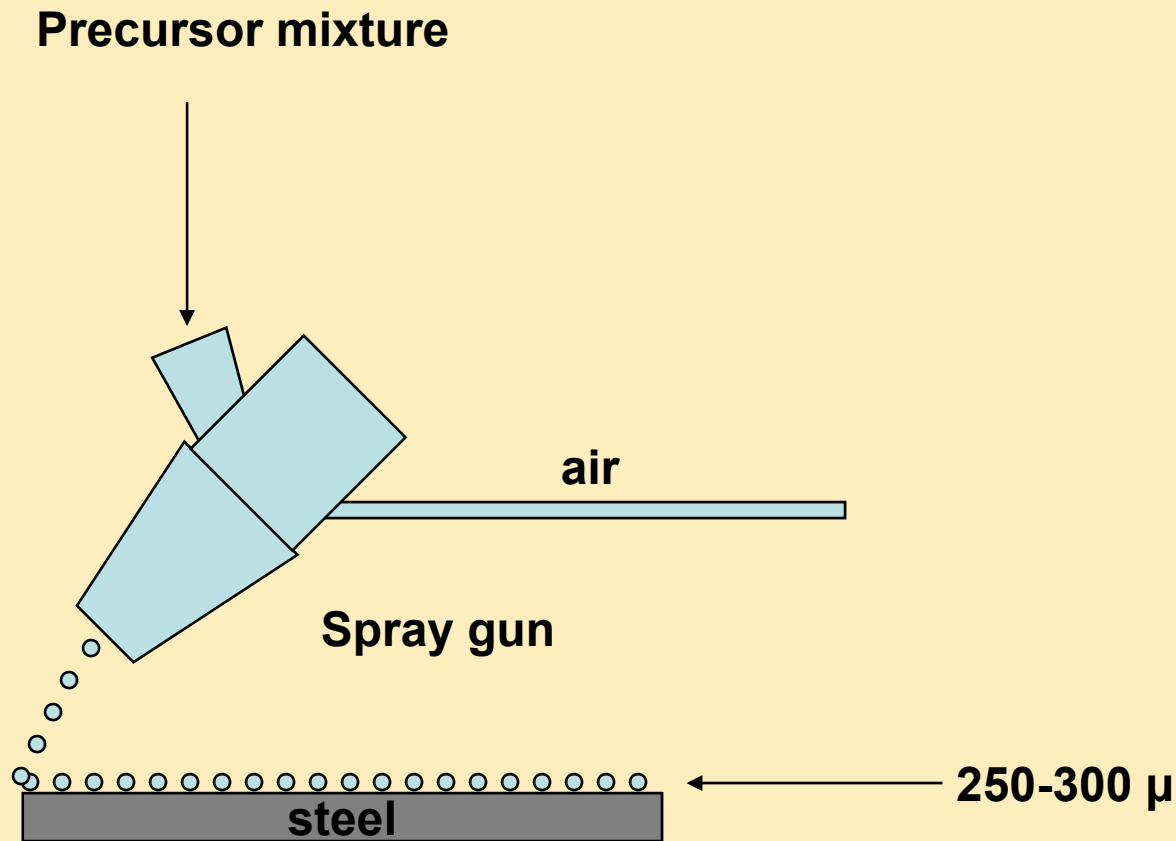
- Laser Induced Surface Improvement
- Uses pre-placed powder (precursor)
- Precursor = Metal powders + Binder
- Dry for few hours
- Laser process

Intermediate layer = Cr + 10.5%CrB<sub>2</sub> + 50% binder

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

# Precursor Deposition

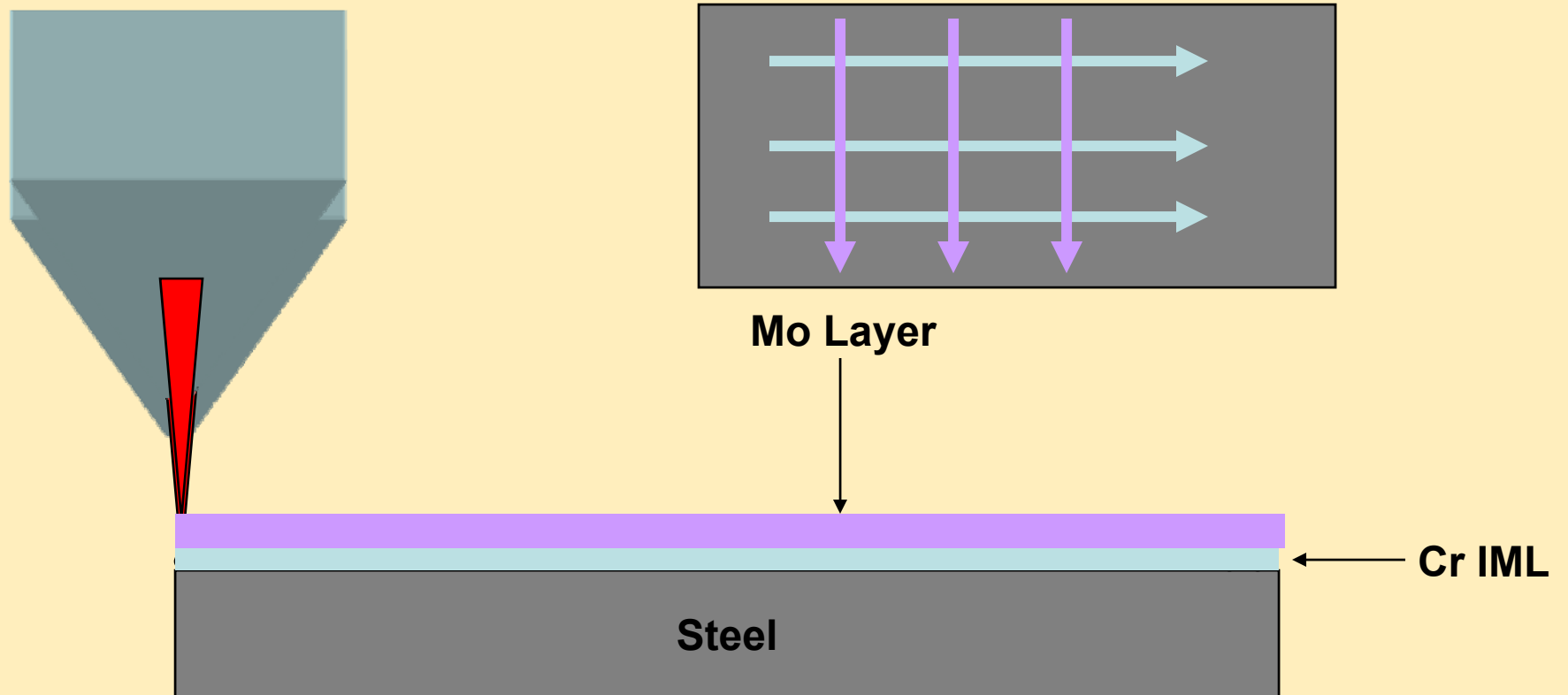
Precursor mixture = Metal Powders + Binder



# Laser Deposition

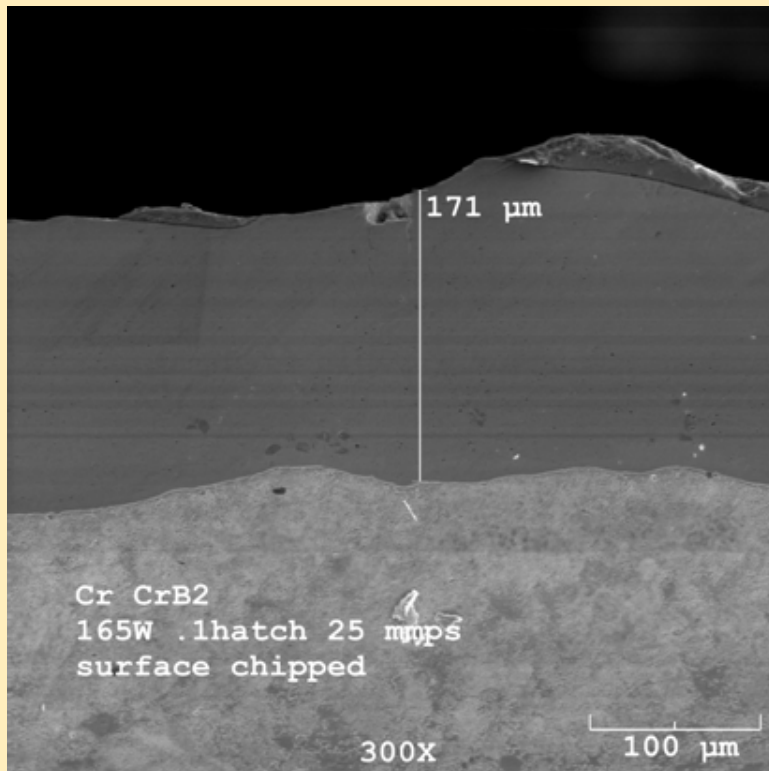
**Cr\* = 165W, 25mm/s, Hatch 0.1mm @ 355nm**

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

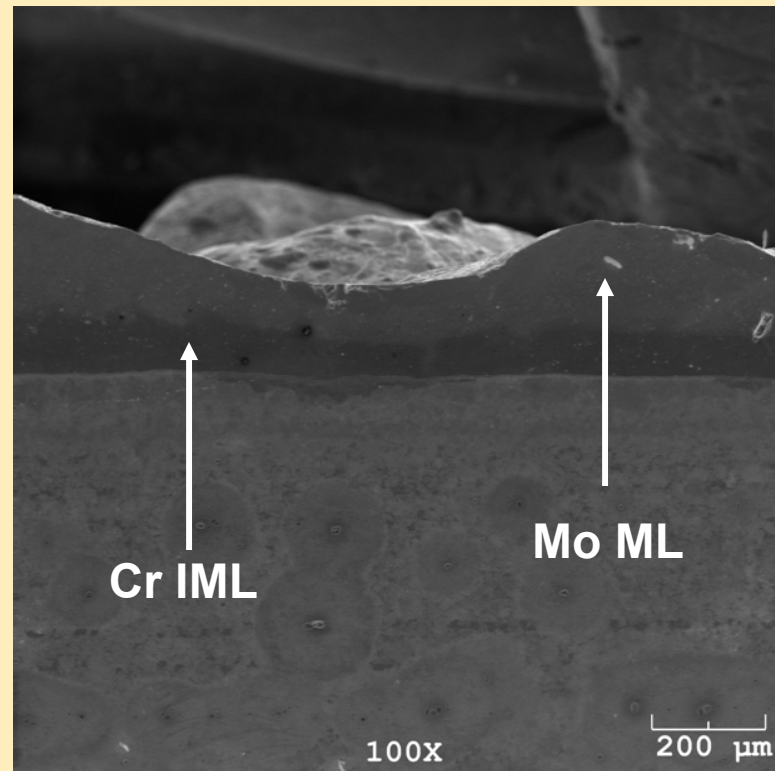


# Coatings

## SEM pictures



**Cr\* Intermediate Layer**



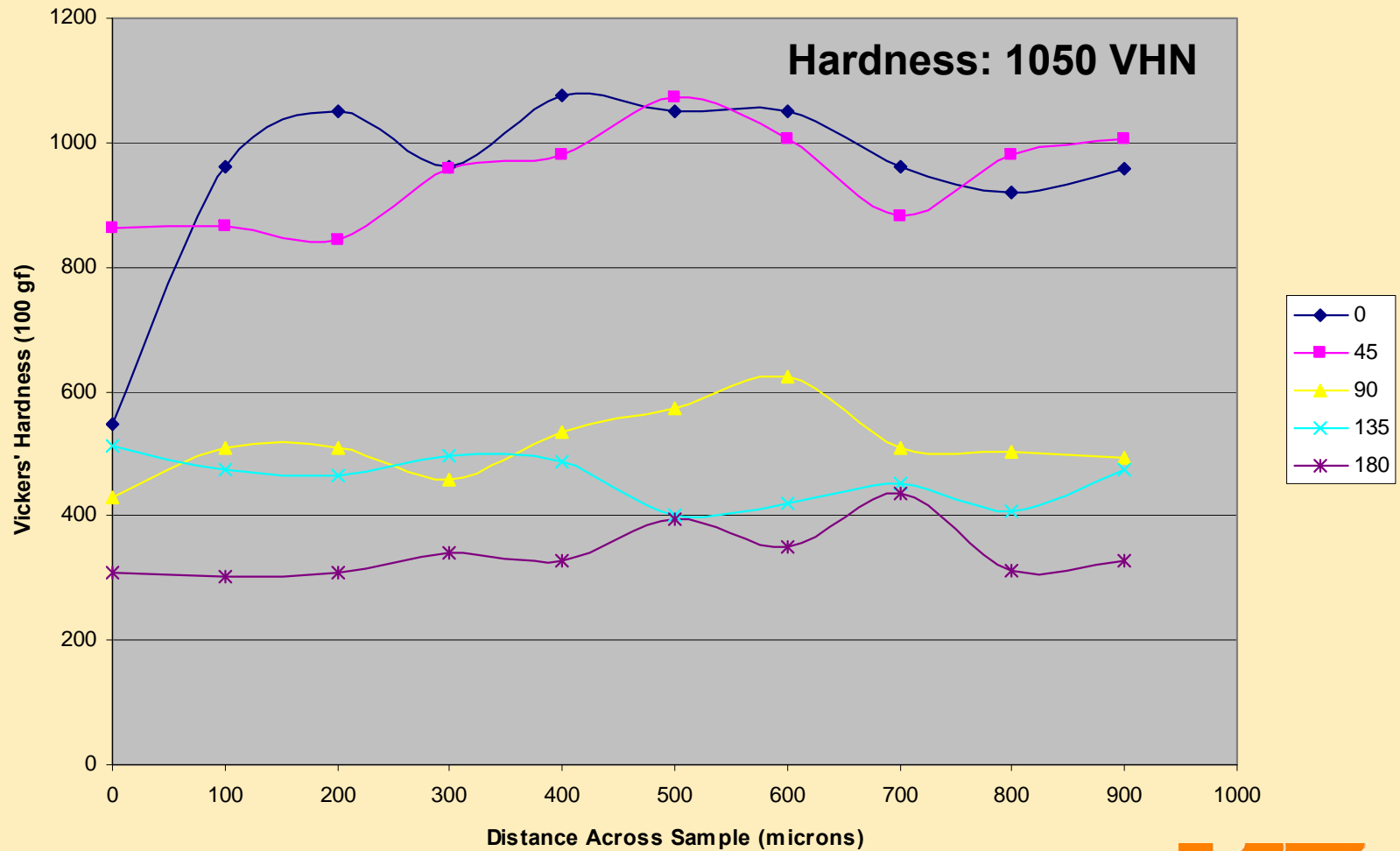
**Mo\* Main Layer**

**Steel Substrate: 4340 Alloy Steel**



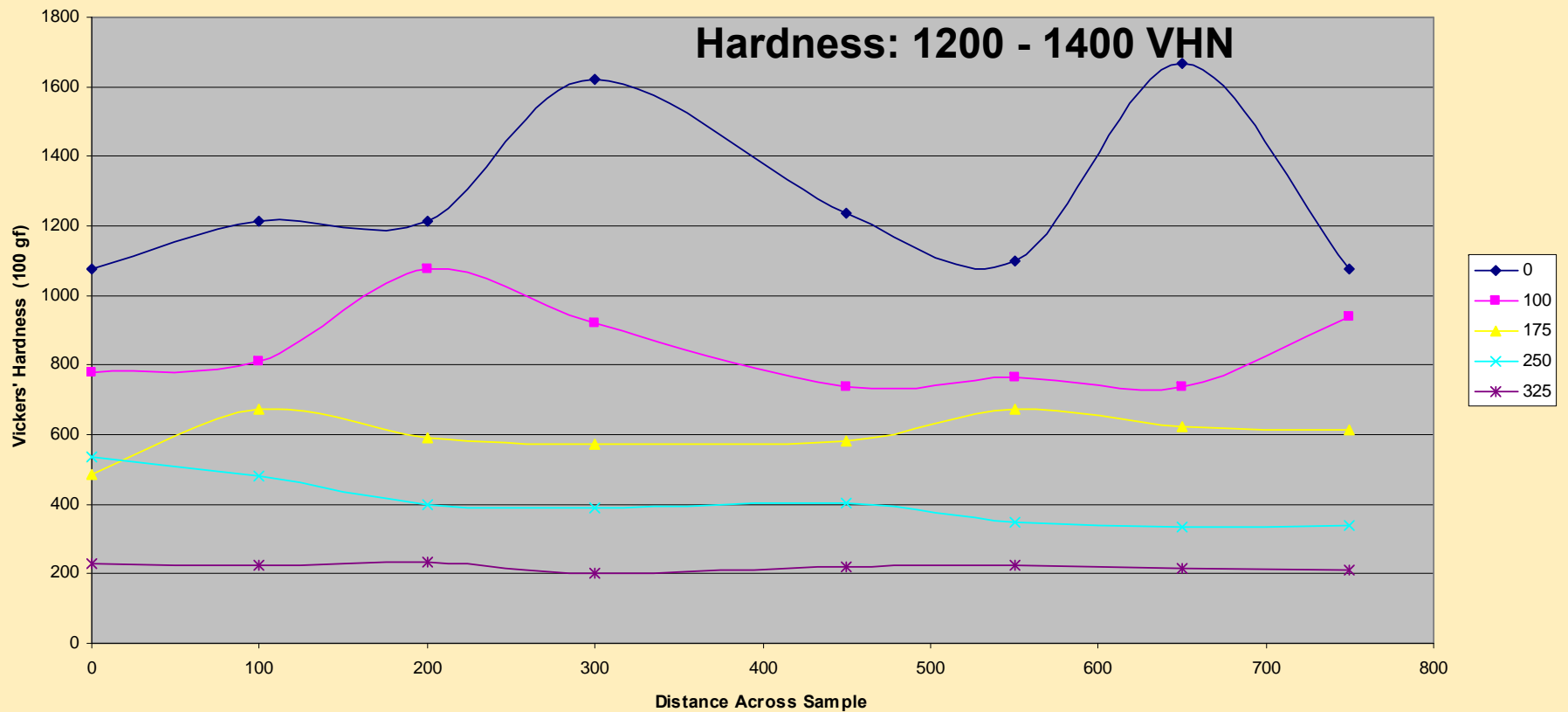
# Microhardness: Cr\* IML

Cr\* on 4340 Steel

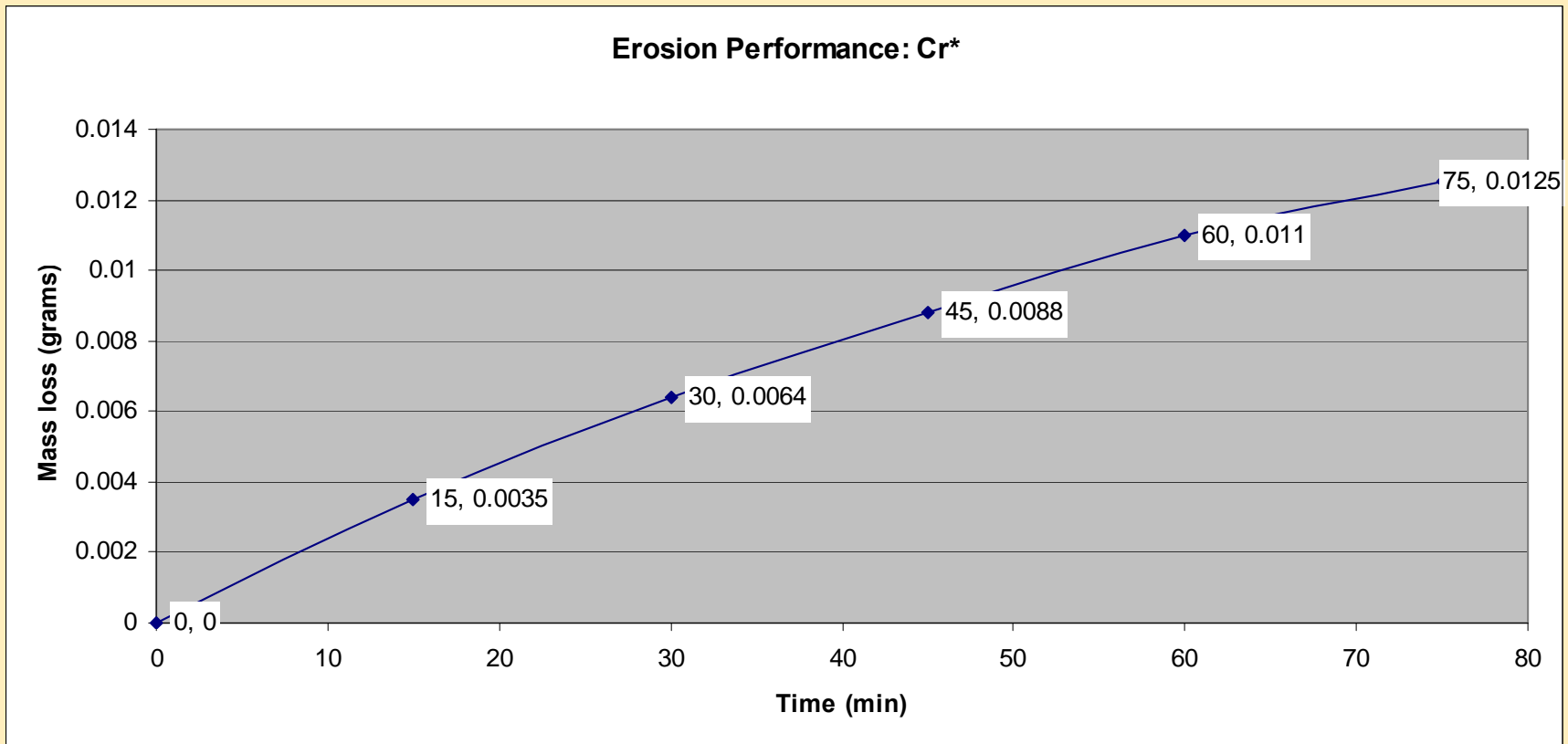


# Microhardness: Mo\* ML

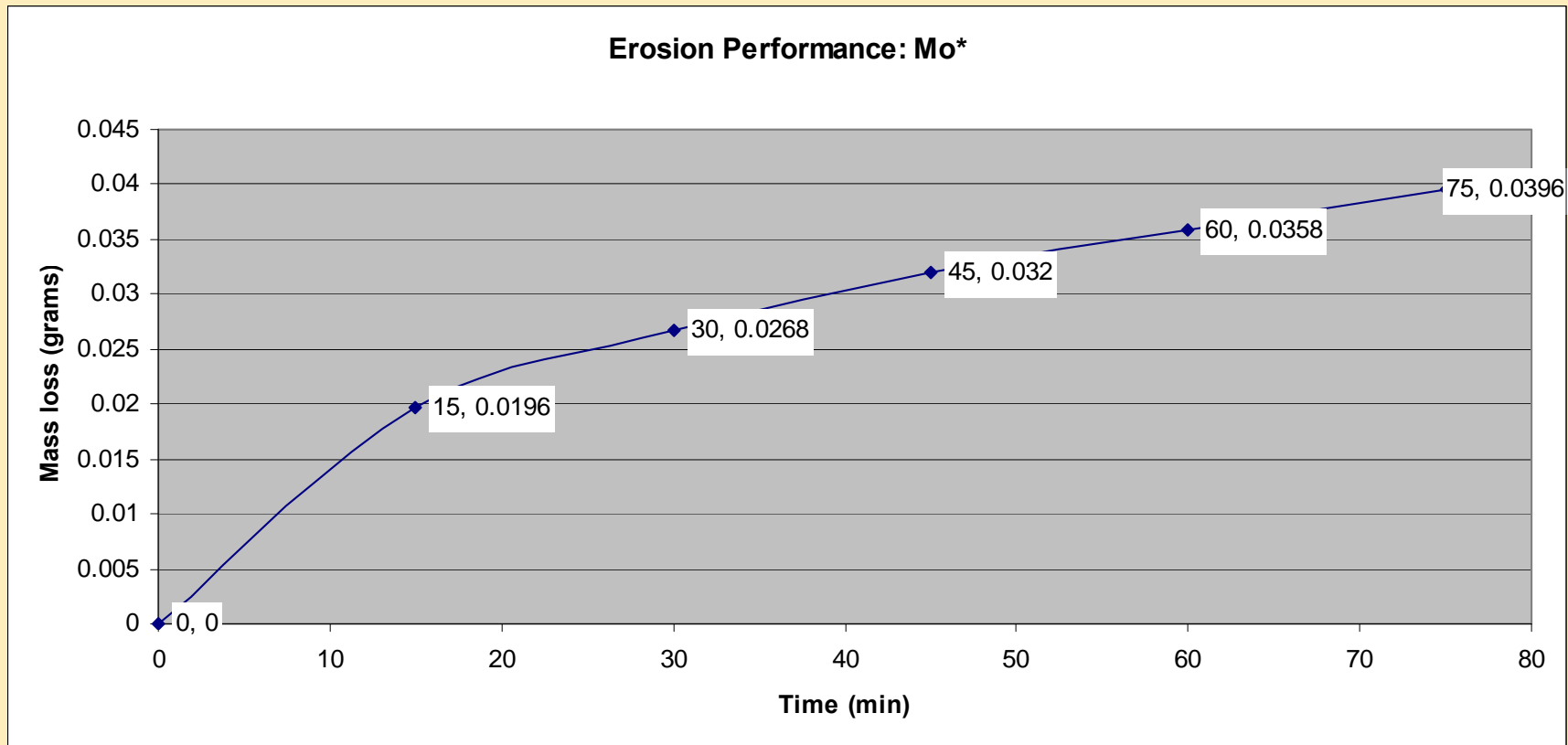
Mo\* on Cr\* on 4340 Steel



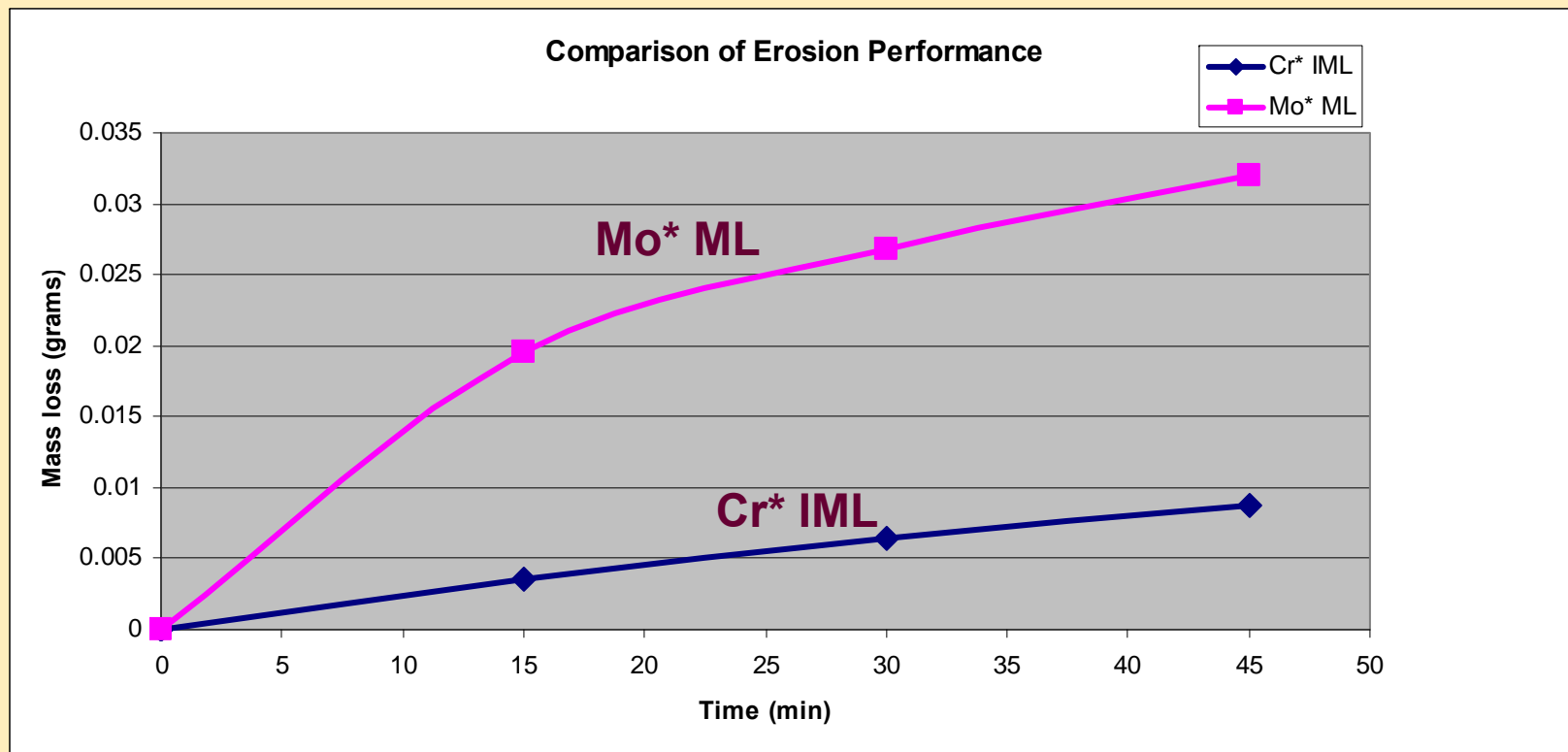
# Erosion: Cr\* IML



# Erosion: Mo\* ML



# Erosion: Comparison



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# 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 !!

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# Further investigation

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

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# Questions

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# Thank You

(I appreciate your patience)