

Project 54: Lubricious PVD Coatings for Forging Dies

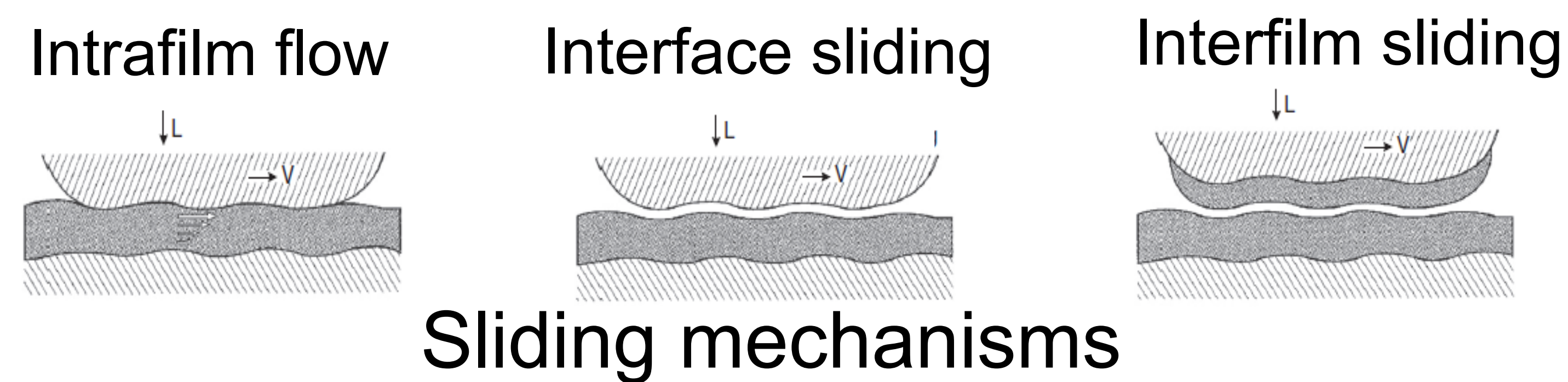
Spring 2022 Semi-Annual Meeting

Student: Jesus Vazquez (Mines), Faculty: Stephen Midson, Andras Korenyi-Both, Kester Clarke (Mines)

Industrial Mentors: Rob Mayer (Queen City Forging), Jose Lozano (Specialty Ring Products through Forging Defense Manufacturing Consortium)

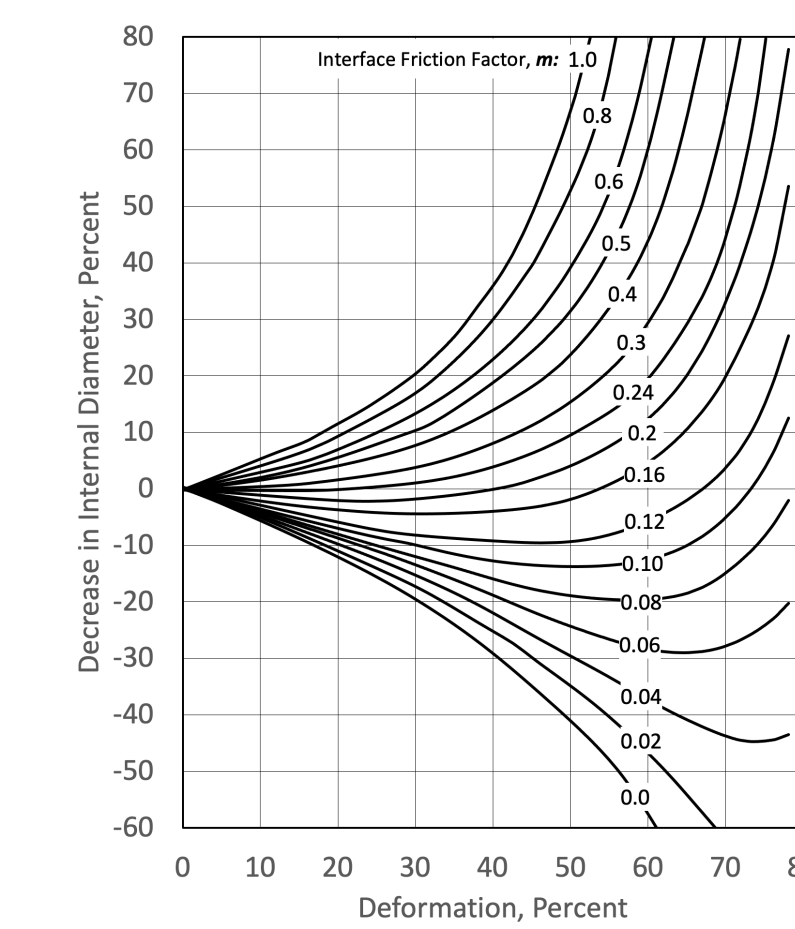
Industrial Relevance:

- **Problem:** Use of lubricants in forging can cause reduced part quality, decreased die life, increased cycle time, environmental and cleanliness issues.
- **Objective:** Obtain PVD coatings and/or texturing for forging die surfaces that reduce friction during metal forging.
- **Benefit:** Improved quality, reduced forging force, improved flow, and minimized material build up.

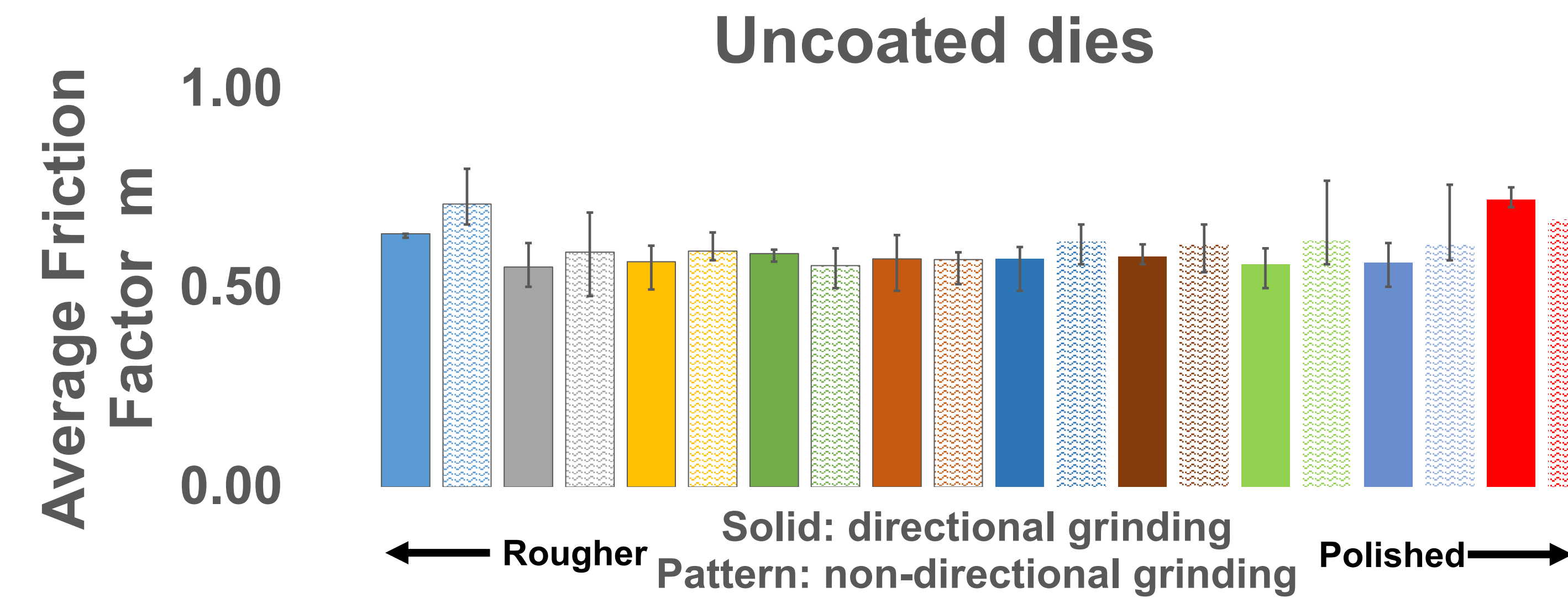


Procedures:

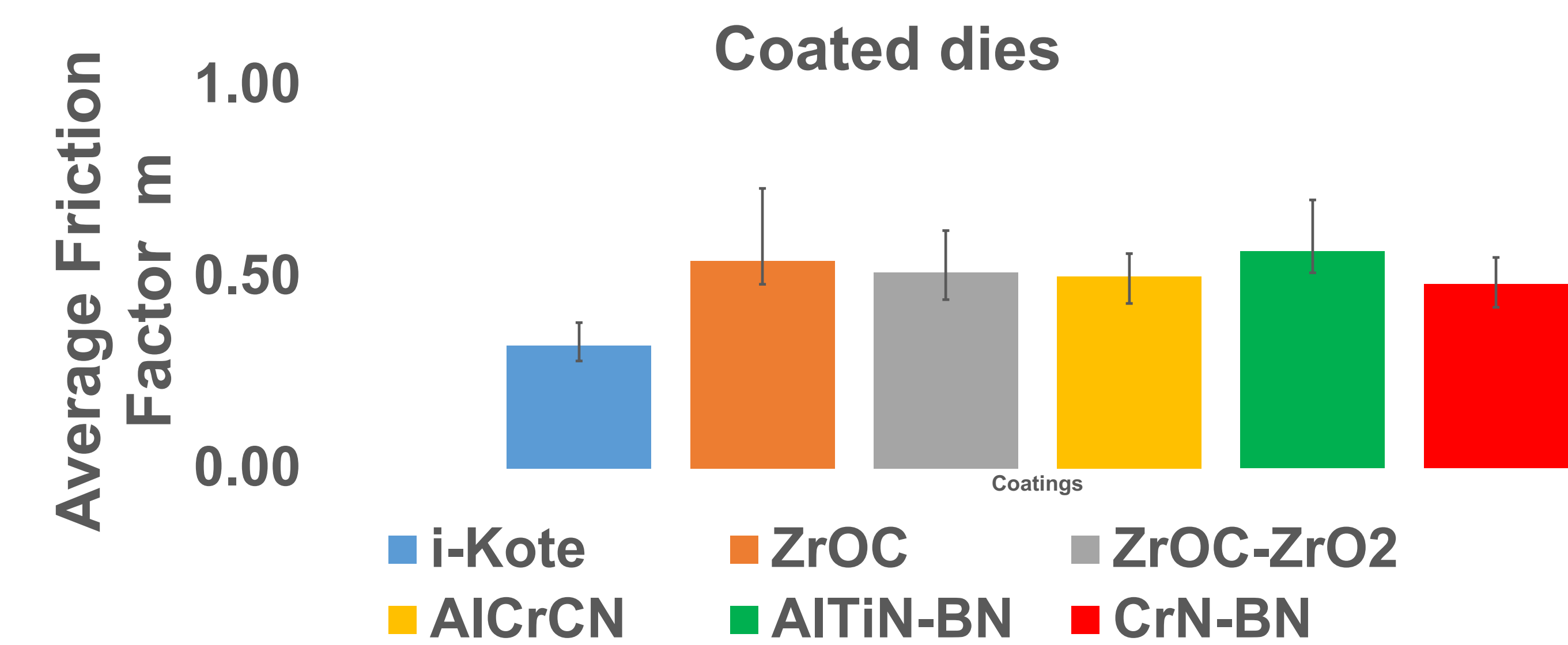
- Use ring forge testing at 425 kN on H13 coated dies of unlubricated 6061-T6 aluminum at room temperature to obtain the friction factor (m)
- Create baseline for uncoated dies with roughness based on grinding from 60 grit up to 1 μ m diamond
- Coatings i-Kote, ZrOC, ZrOC-ZrO₂, AlCrCN, AlTiN-BN, CrN-BN



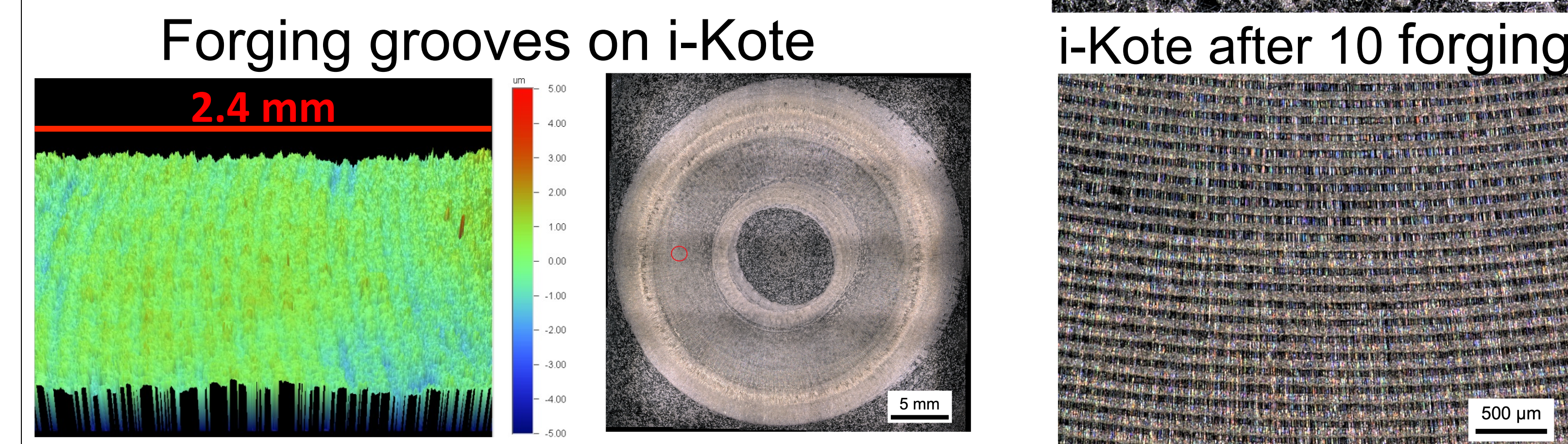
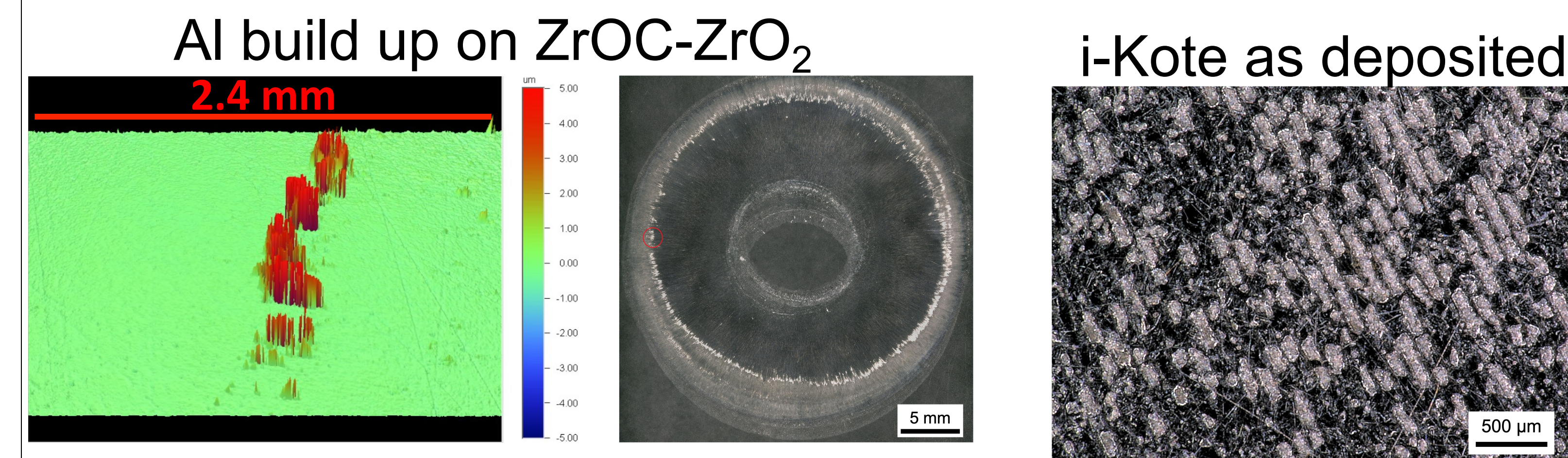
Results:



Surface roughness effects on friction factor m



Coatings effects on friction factor m



Conclusions:

- Uncoated dies showed highest value of friction factor (m) at the roughest and most polished surfaces regardless of grinding direction.
- Coated dies reduced the friction factor (m) during forging compared to uncoated dies.
- i-Kote showed the lowest value of $m = 0.32$ compared to a maximum $m = 0.57$ on AlTiN-BN and $m = 0.72$ on an uncoated polished die.
- Grooves appeared on the i-Kote forging area
- Al build up was reduced on the coated dies.

Future Work:

- Continue literature review.
- Investigate topographies that reduce friction.
- Microstructure characterization.
- New coatings: i-Kote WS₂, i-Kote-BN, VCN, DLC.
- Elevated temperature testing.
- Fabricate heated die holders.
- Set up for 1800 kN (400-kip) press.

Acknowledgments:

- Defense Logistics Agency (DLA)
- Queen City Forging Co.
- Specialty Ring Products; Forging Defense Manufacturing Consortium (FDMC)
- Forging Industry Educational and Research Foundation

