

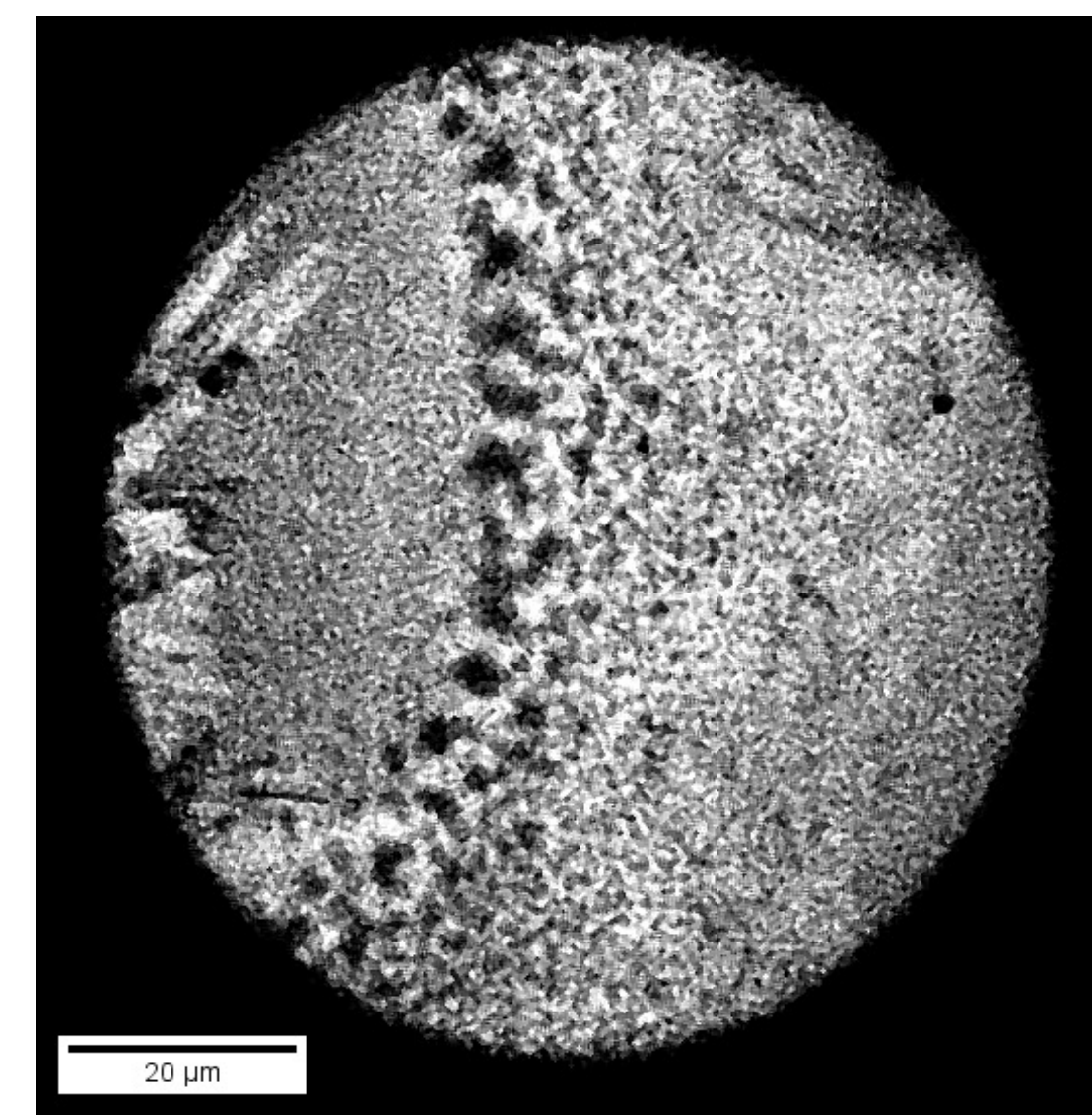
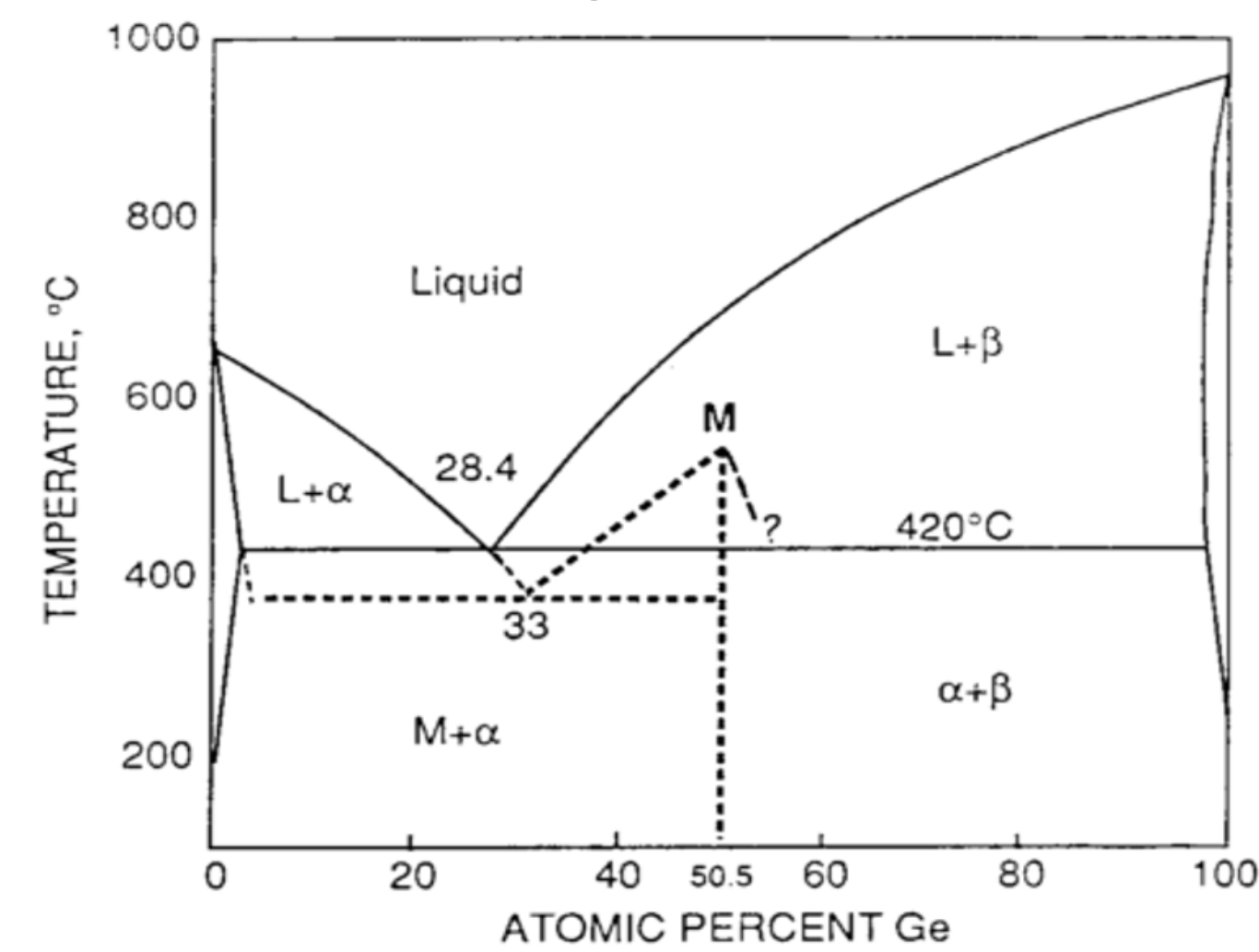
# Project 59-L: In-situ Visualization of Microstructure Evolution in Metallic Alloys Under Additive Manufacturing Conditions

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## Background:

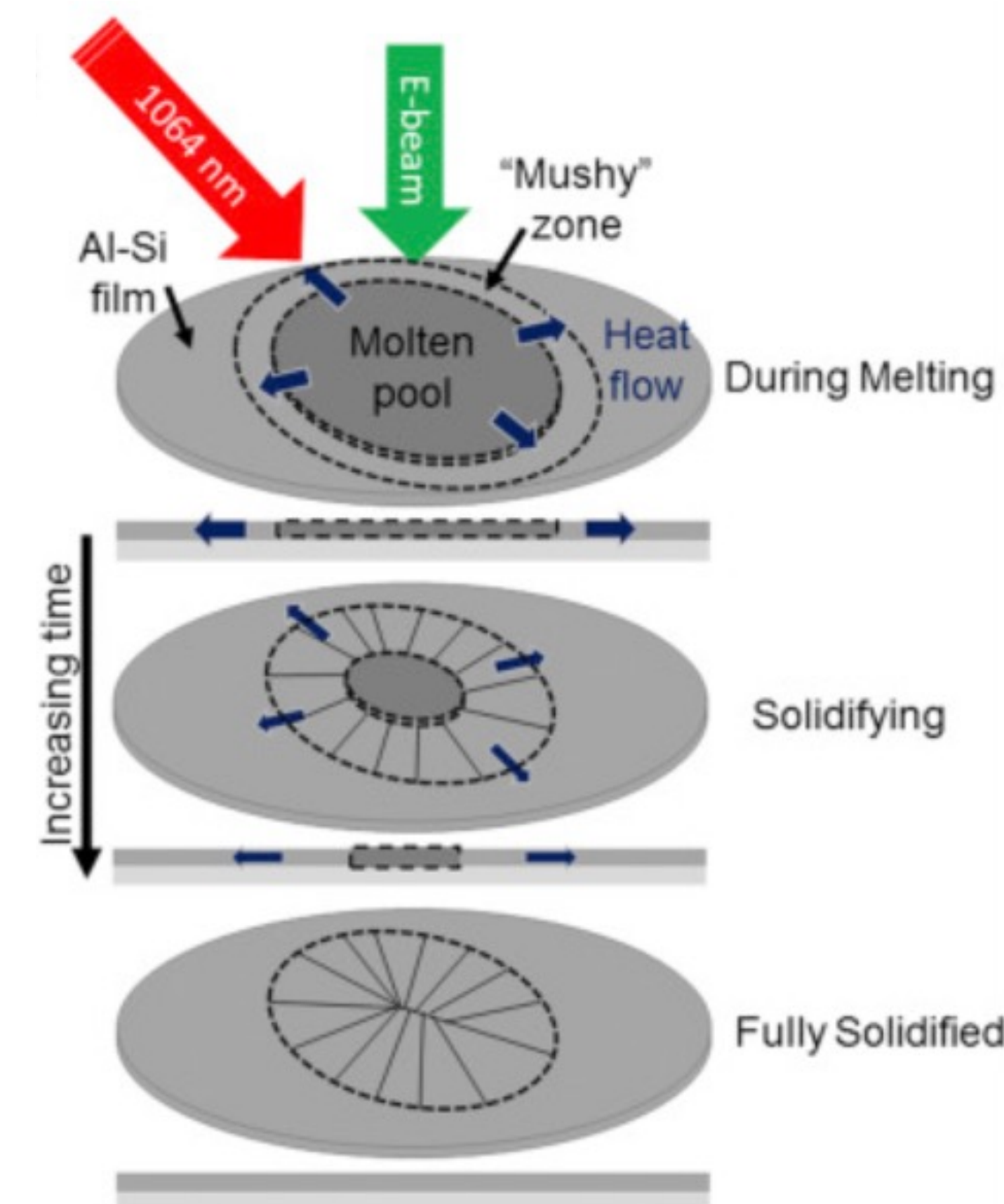
- Grain competition at high solidification velocities in Al-Si alloys is needed to inform phase field modeling.
- The origin of grain refinement in novel Ti alloys designed for additive manufacturing (AM) is not well understood.
- The Al-Ge system has been reported to form metastable phases during rapid solidification.



Al-Ge melt pool capturing monoclinic (M) phase growth.

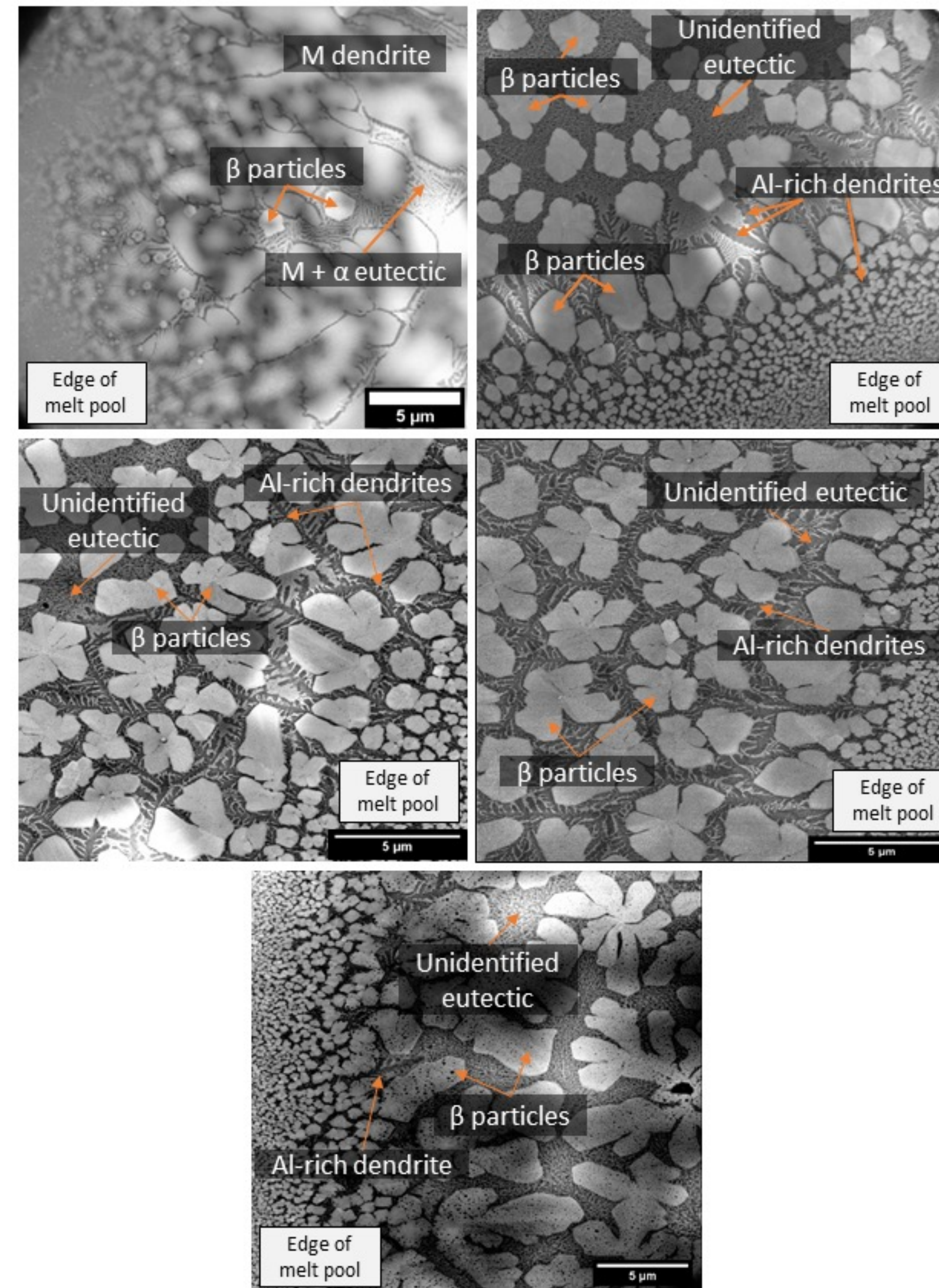
## Procedures:

- DTEM and in-situ radiography to capture local solidification conditions in the melt pools.
- Ex-situ observation through SEM and TEM at Mines for additional analyses.
- Estimated solidification velocities of Al-Si to inform phase field modeling of rapid solidification dynamics.
- Post-mortem STEM and EDS data to determine resulting phases and microstructures.



Diagrammed time sequence of melting and solidification of the alloy film by DTEM [2].

## Ex-situ Al-Ge Analysis:

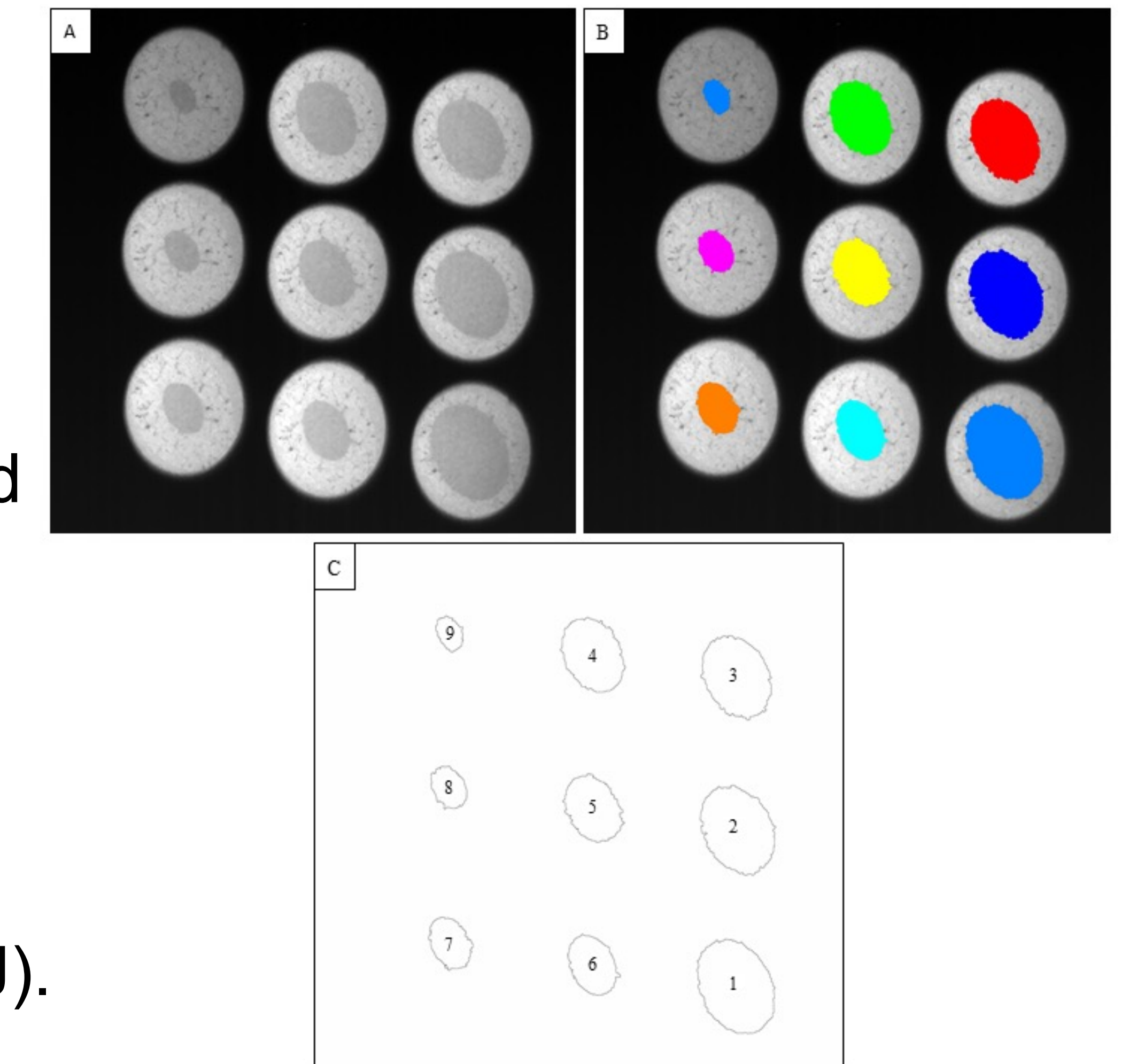


Ex-situ HAADF TEM images of melt pools from Al-Ge DTEM samples of differing compositions.

## In-situ Al-Si Solidification Velocity Determination:

### Determination:

- Non-local means filter (Avizo).
- Segmented melt pools using adaptive threshold tool (Avizo).
- Outlines of melt pools used to measure solidification velocities (ImageJ).



## Future Work:

- Identify eutectics in Al-Ge samples.
- TEM with nanoscale crystallographic mapping with ASTAR at Mines for additional microstructure characterization.
- Prepare a peer-reviewed journal manuscript on Al-Ge microstructure development under rapid solidification conditions.
- Al-Si microstructure characterization to inform phase field modeling and understanding of competitive grain growth during rapid solidification.
- Study novel Ti alloys matched to AM processing that develop grain refinement.

### References:

- [1] T. Laoui, M.J. Kaufman, "Nonequilibrium Behavior in the Al-Ge Alloy System: Insights into the Metastable Phase Diagram", *Metallurgical Transactions A*. 22 (1991) 2141-2152.
- [2] J. D. Roehling, et al. Rapid Solidification Growth Mode Transitions in Al-Si Alloys by Dynamic Transmission Electron Microscopy, *Acta Materialia*. 131 (2017) 22-30.

### Acknowledgements:

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