

Reacting CMAS with Yttrium Disilicate Environmental Barrier Coating

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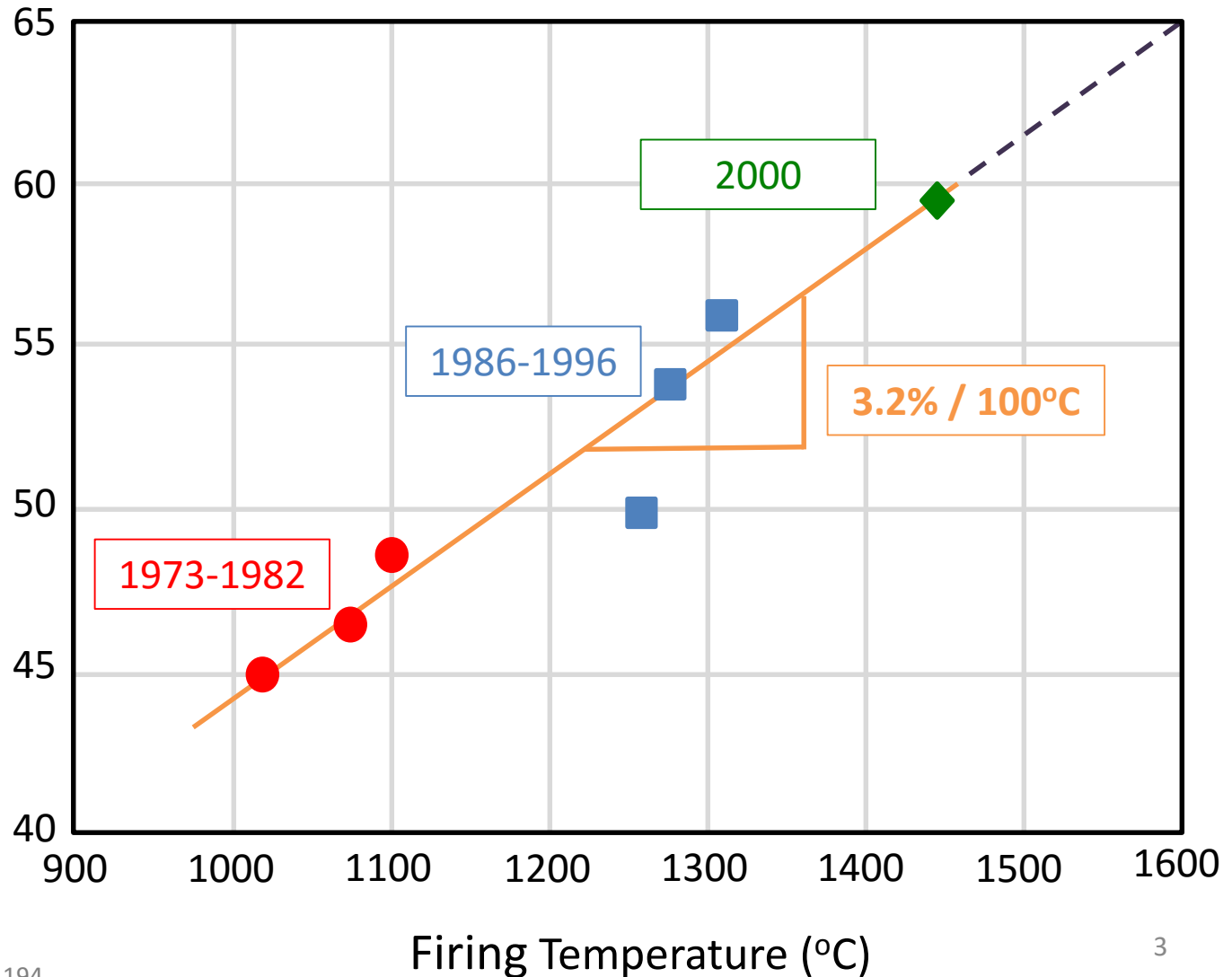
Department of Materials

Silicon carbide ceramic matrix composites (SiC CMCs) likely to replace nickel alloys



Raising firing temperature improves engine efficiency

Combined Cycle Efficiency (%)

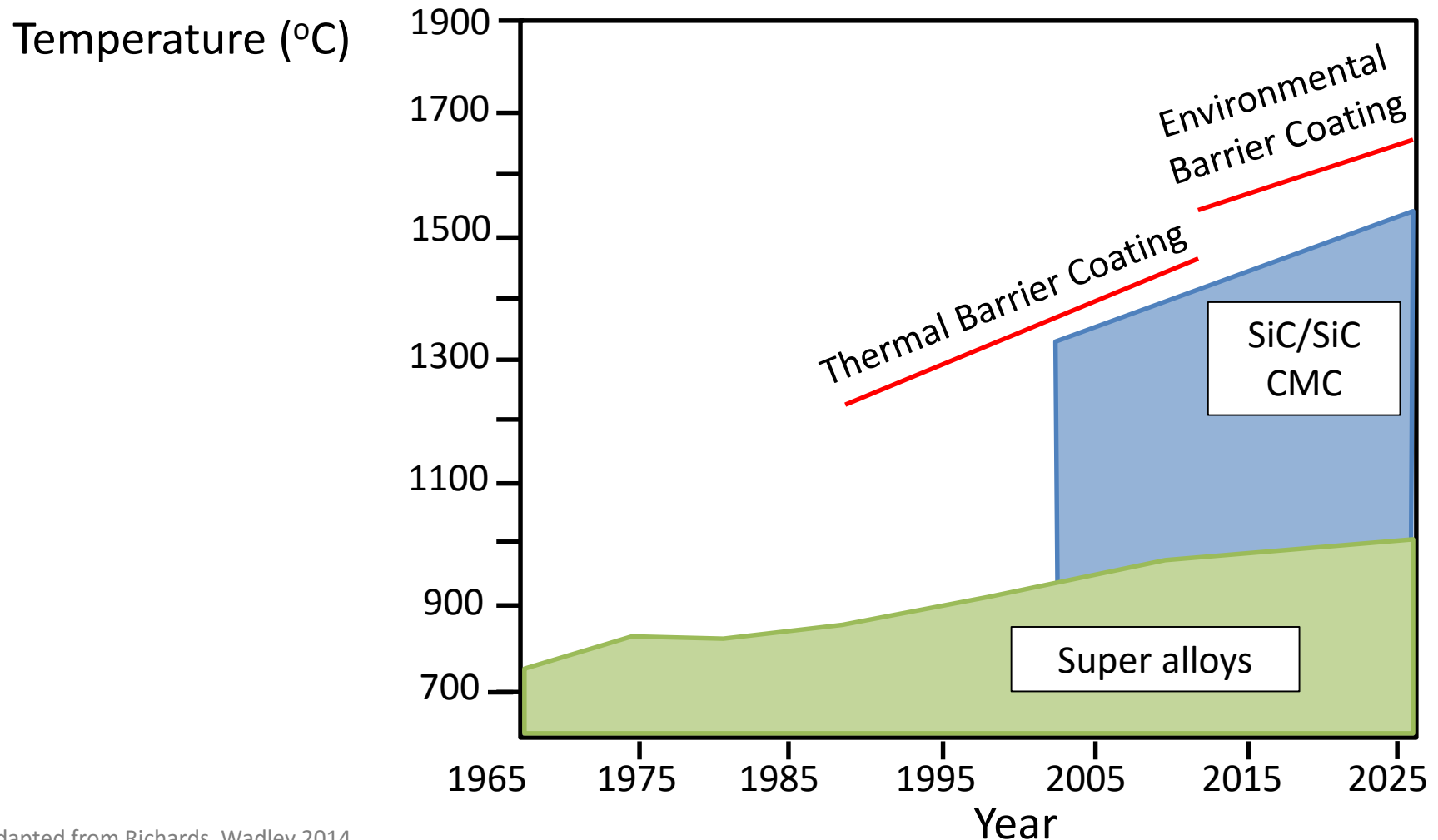


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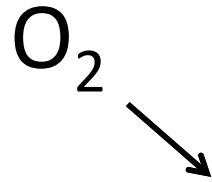


Images courtesy GE Aviation

Silicon carbide ceramic matrix composites (SiC CMCs) likely to replace nickel alloys

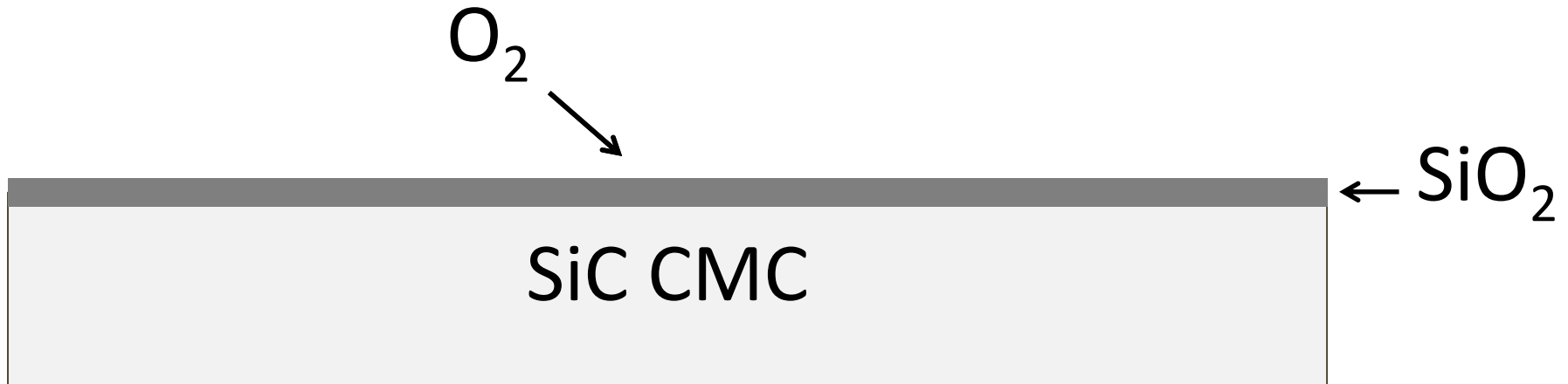


Without Environmental Barrier Coating

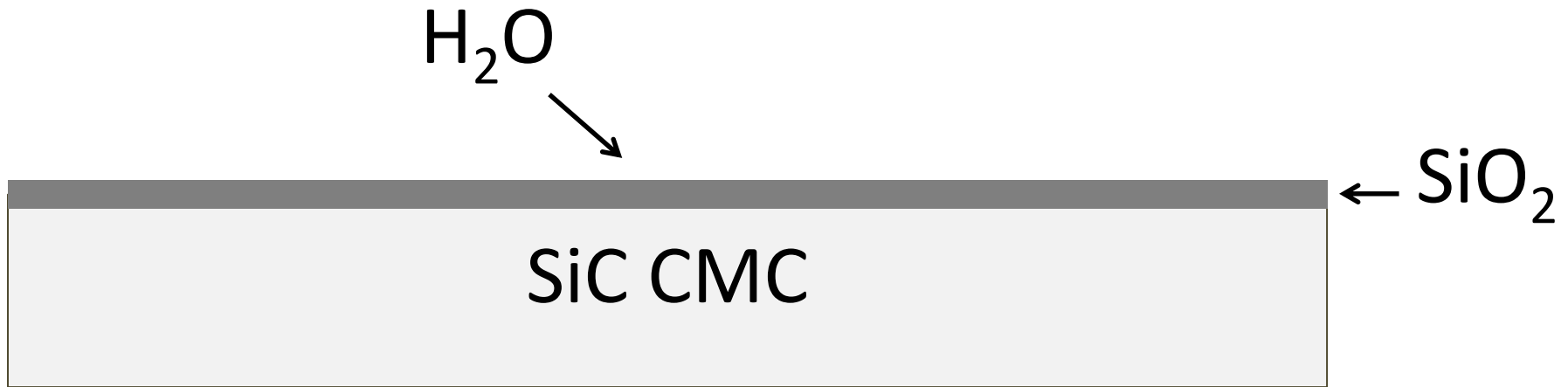


SiC CMC

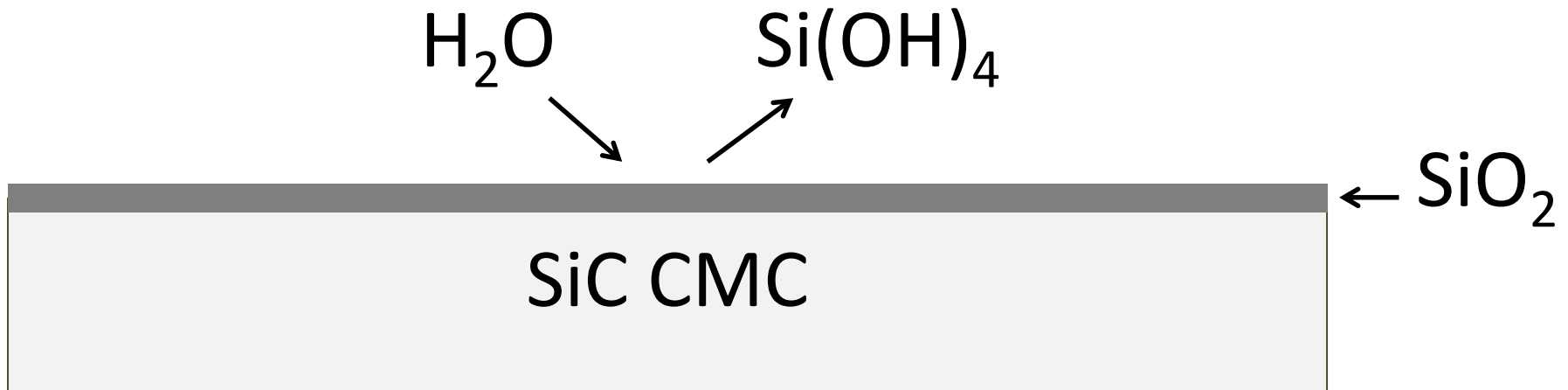
Without Environmental Barrier Coating



Without Environmental Barrier Coating



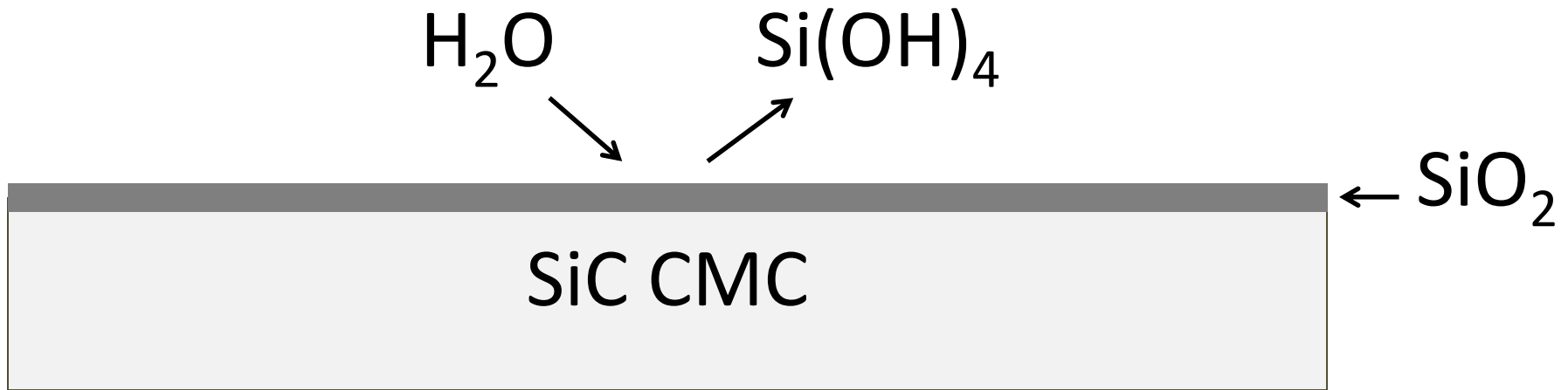
Without Environmental Barrier Coating



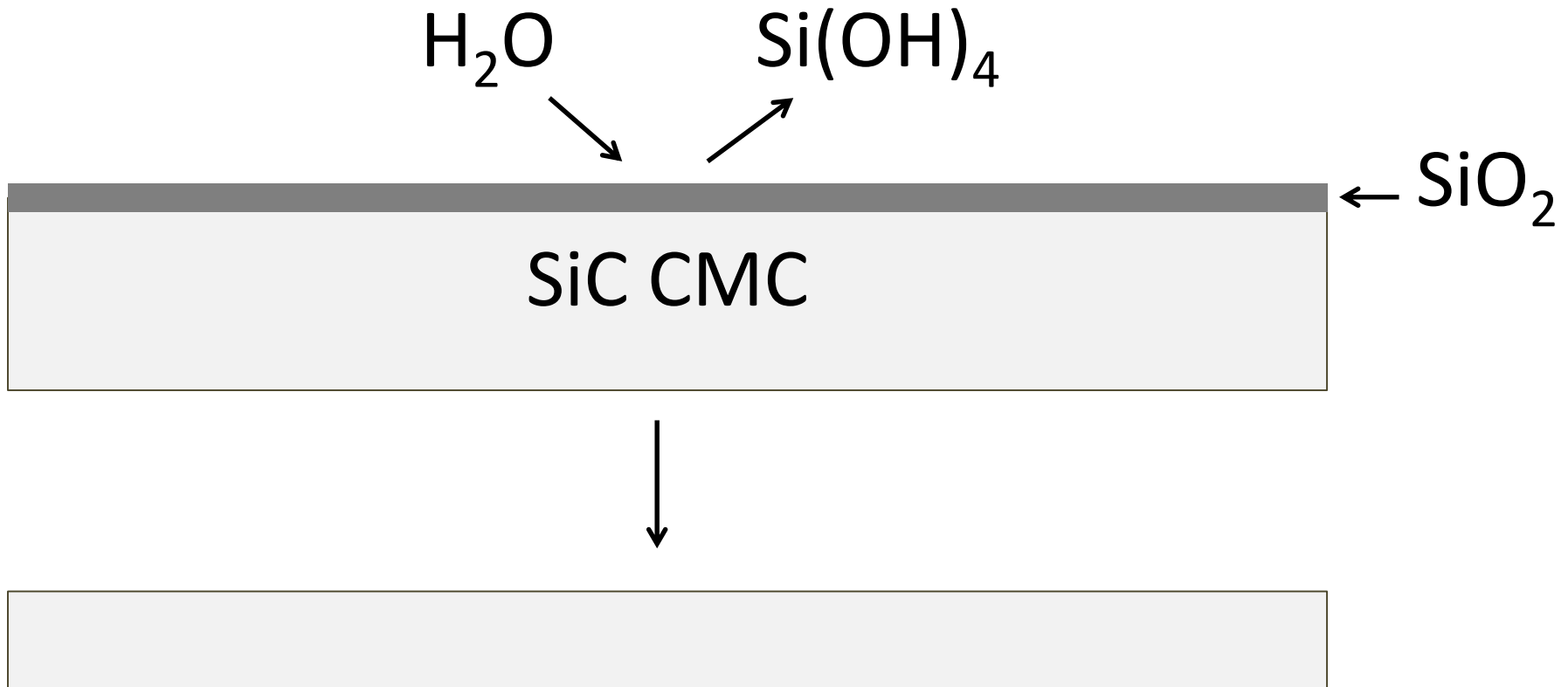
Without Environmental Barrier Coating

SiC CMC

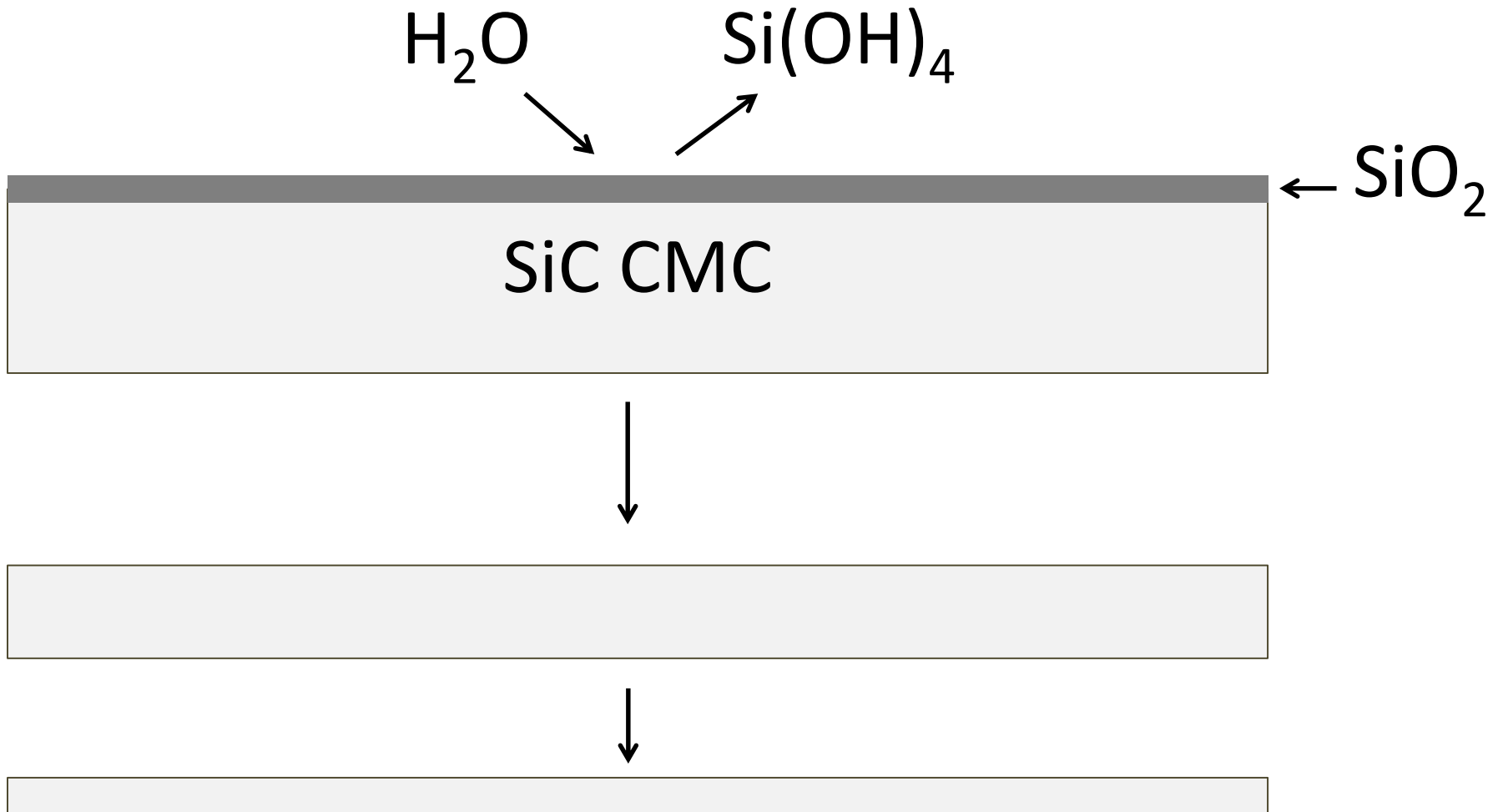
Without Environmental Barrier Coating



Without Environmental Barrier Coating



Without Environmental Barrier Coating



With Environmental Barrier Coating

EBC

SiC CMC

With Environmental Barrier Coating

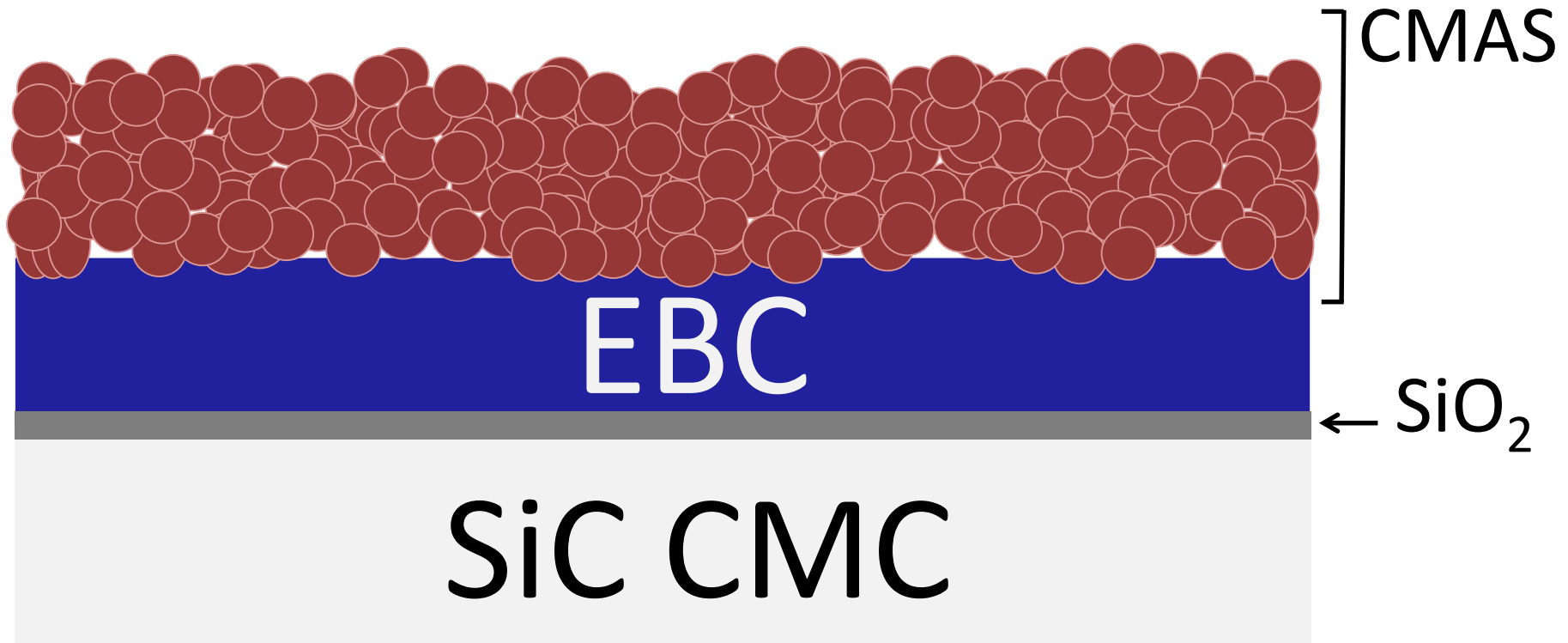


EBC

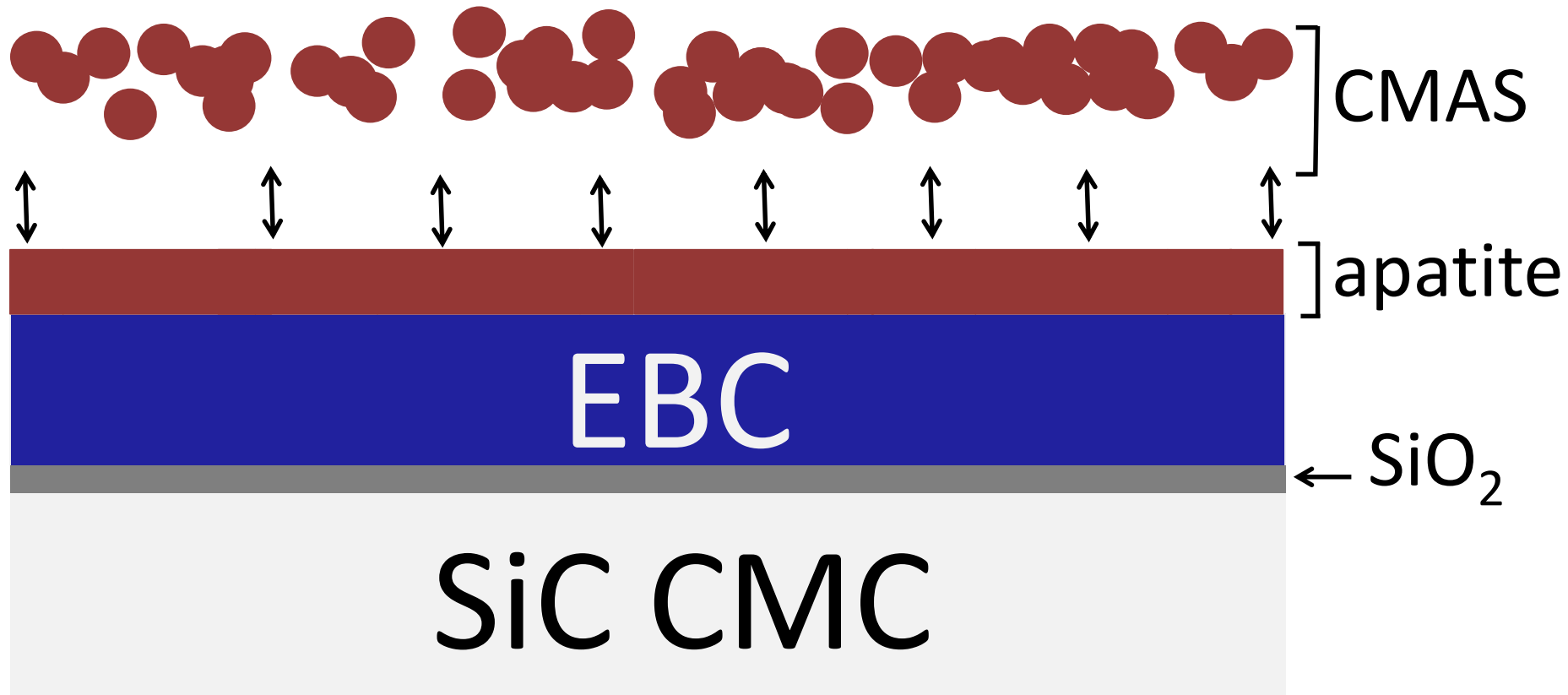
SiC CMC

With Environmental Barrier Coating

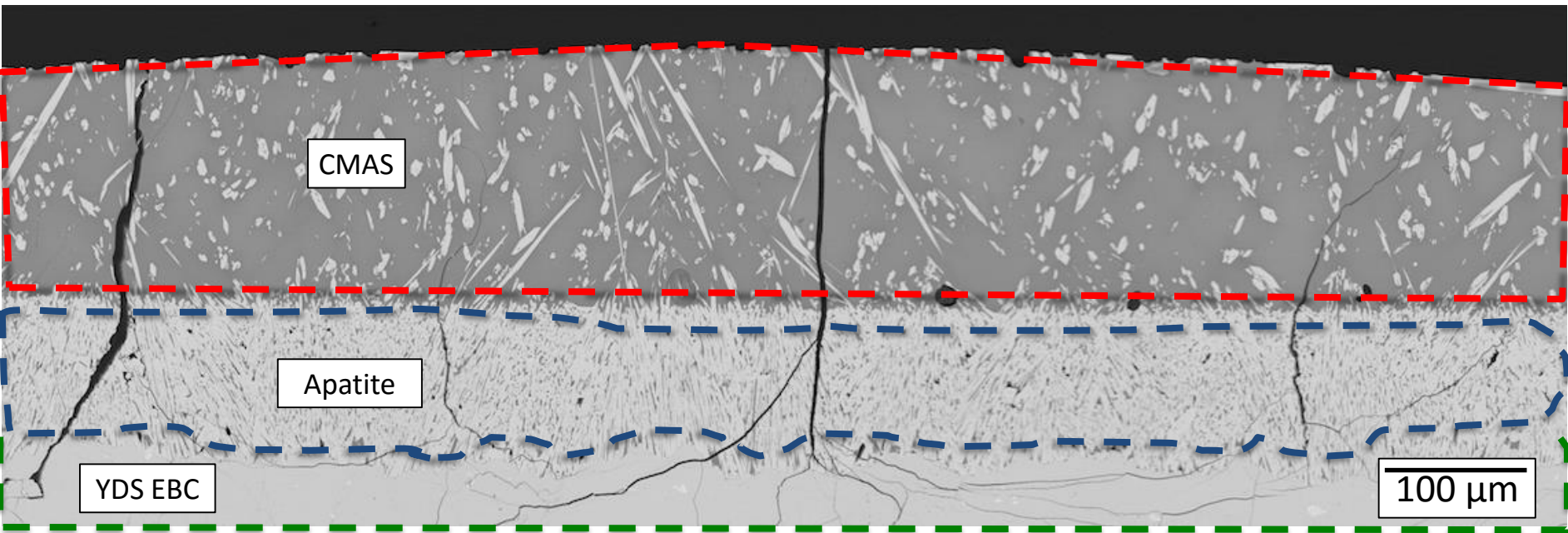
- CMAS: Calcium-Magnesium-Alumina-Silicate
- Siliceous materials, desert sand to volcanic ash



With Environmental Barrier Coating

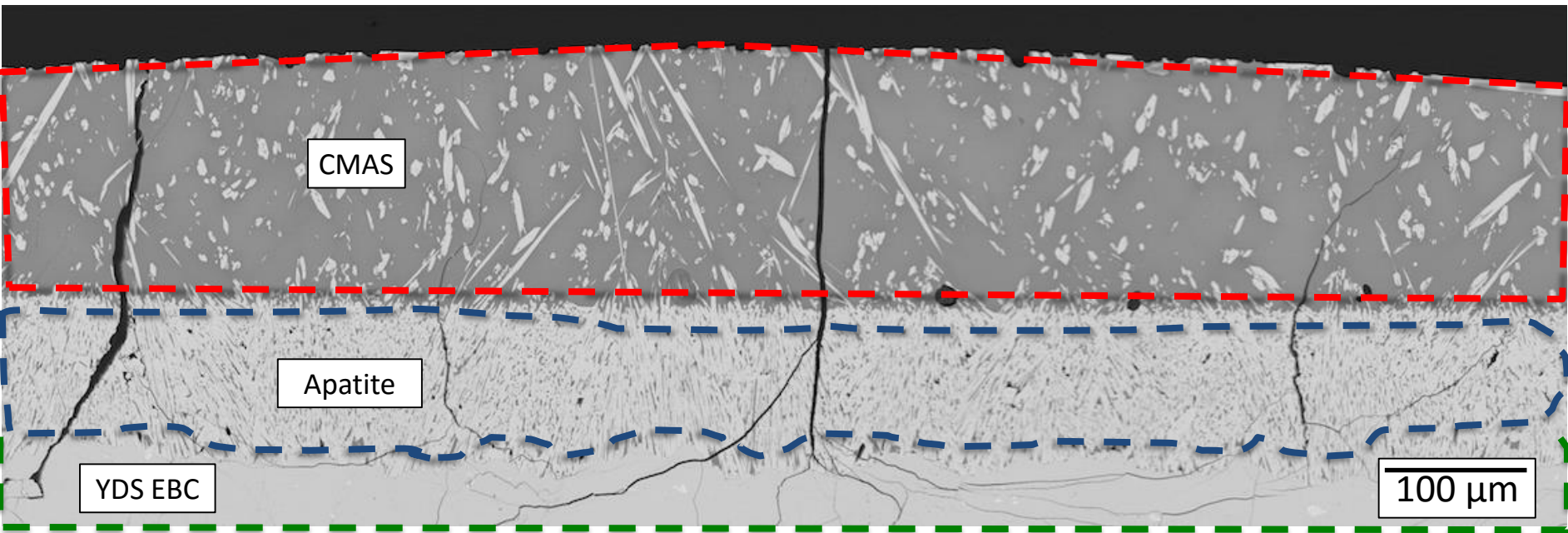


Apatite byproduct causes cracks to form in environmental barrier coating layer



$(\text{CaO})_{31\%}(\text{MgO})_{9\%}(\text{FeO}_{1.5})_{5\%}(\text{AlO}_{1.5})_{12\%}(\text{SiO}_2)_{43\%}$ at 1400°C – 4 hours

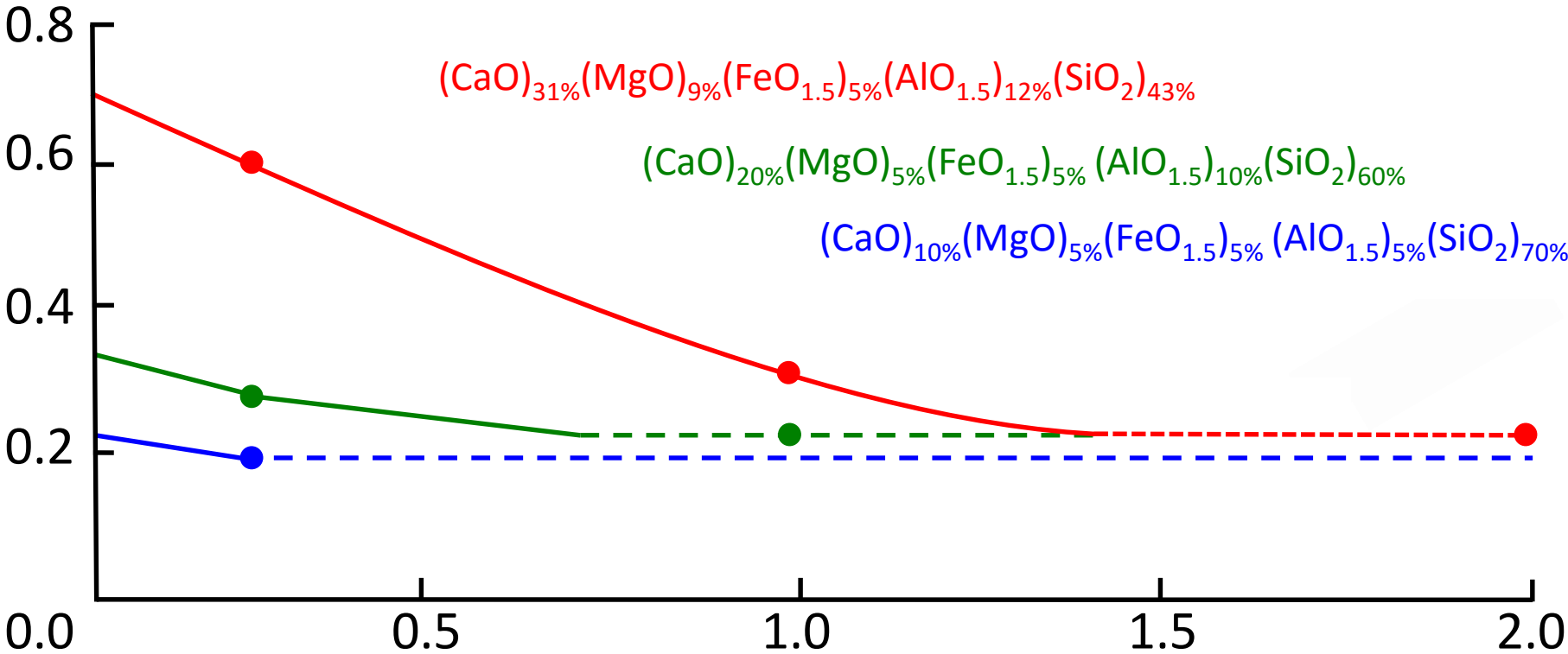
Apatite byproduct causes cracks to form in environmental barrier coating layer



How can we prevent or mitigate the reaction between the EBC and CMAS?

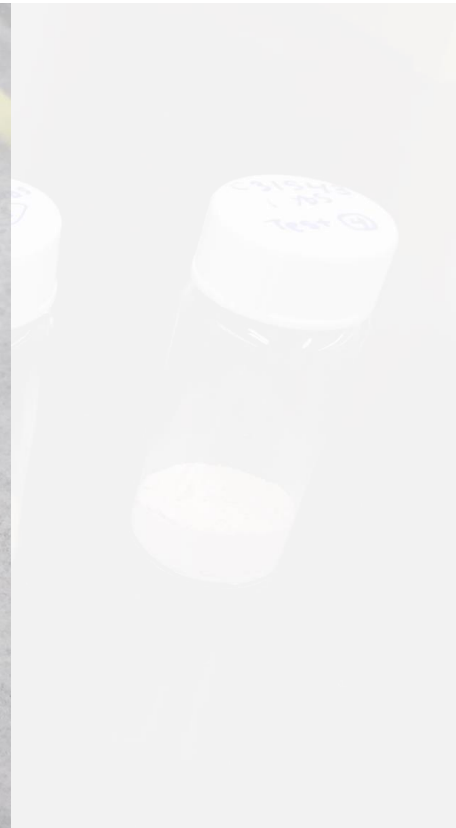
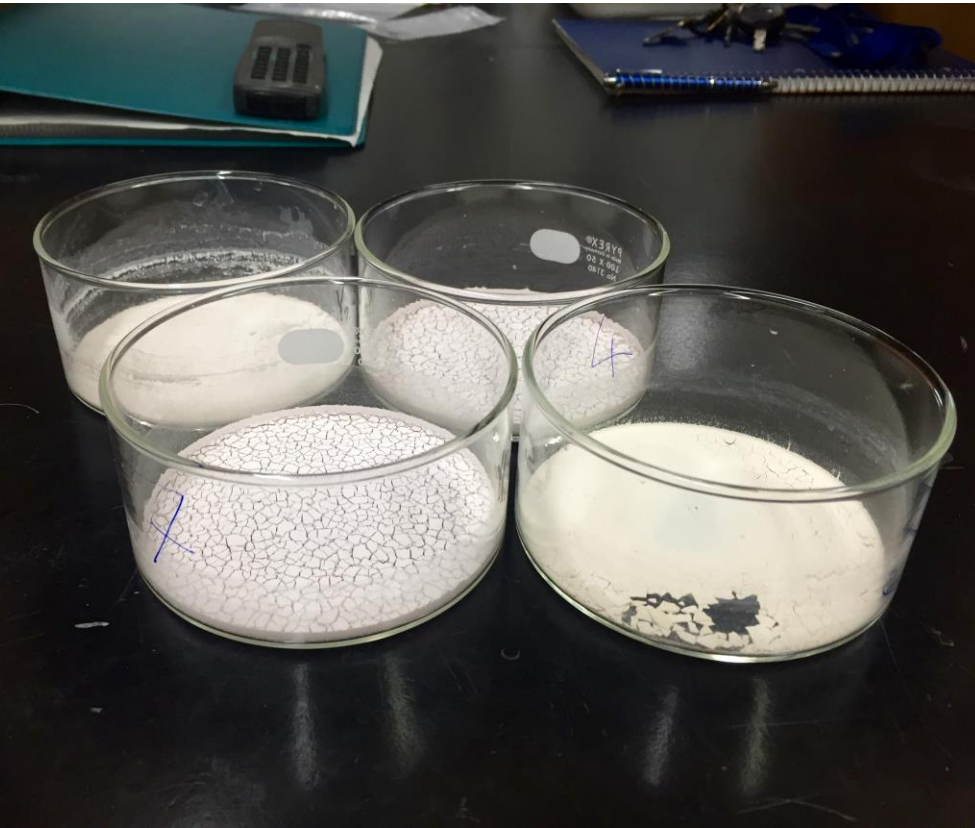
Predicted Equilibria

Calcium to Silica Mol Ratio

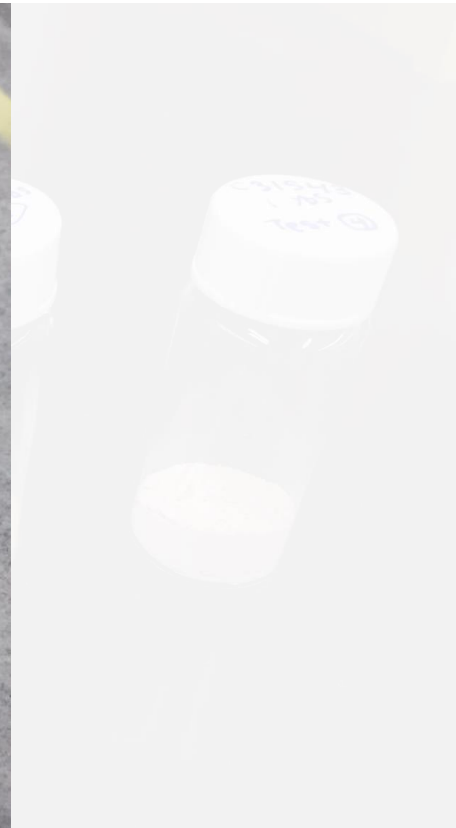


Mol of Yttrium Disilicate EBC Consumed

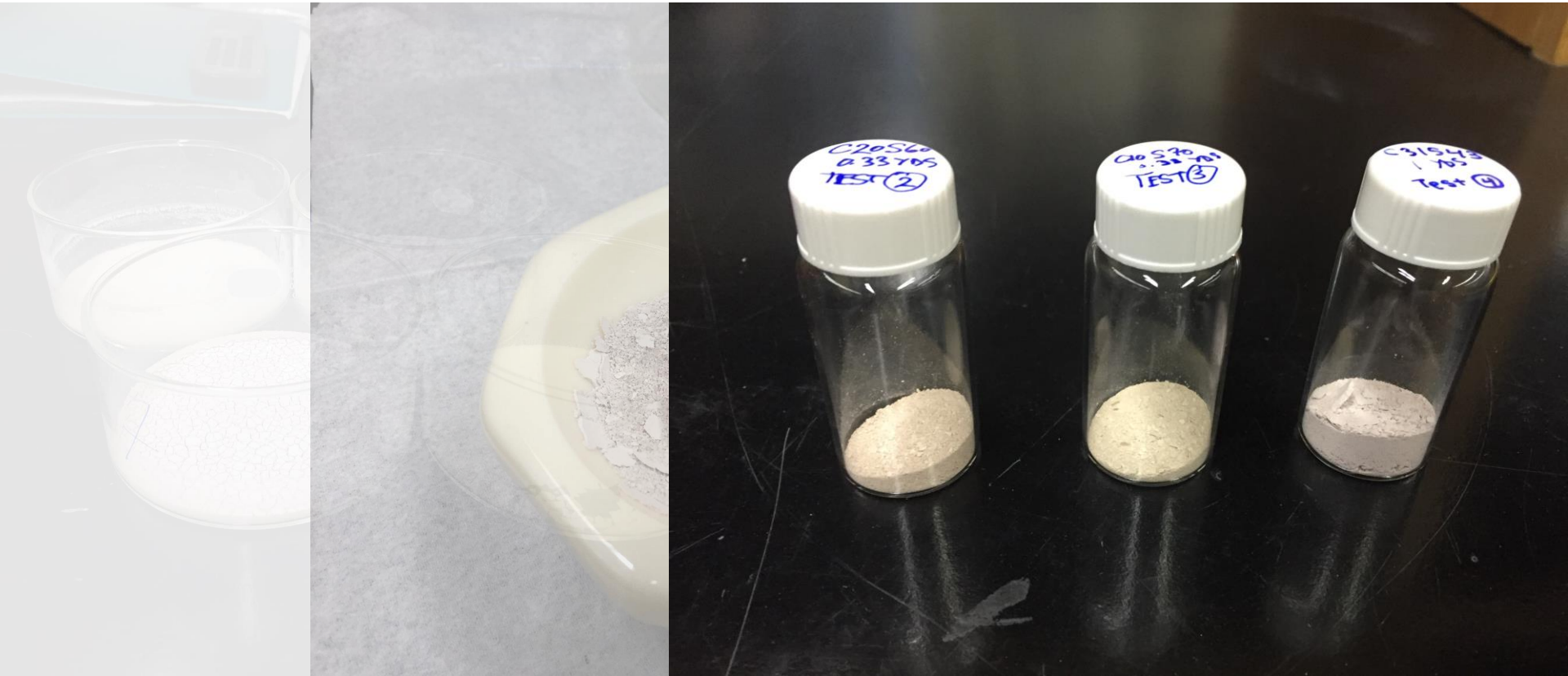
Prepare and Grind Powders



Prepare and Grind Powders



Prepare and Grind Powders



Press Powders Into Pellets



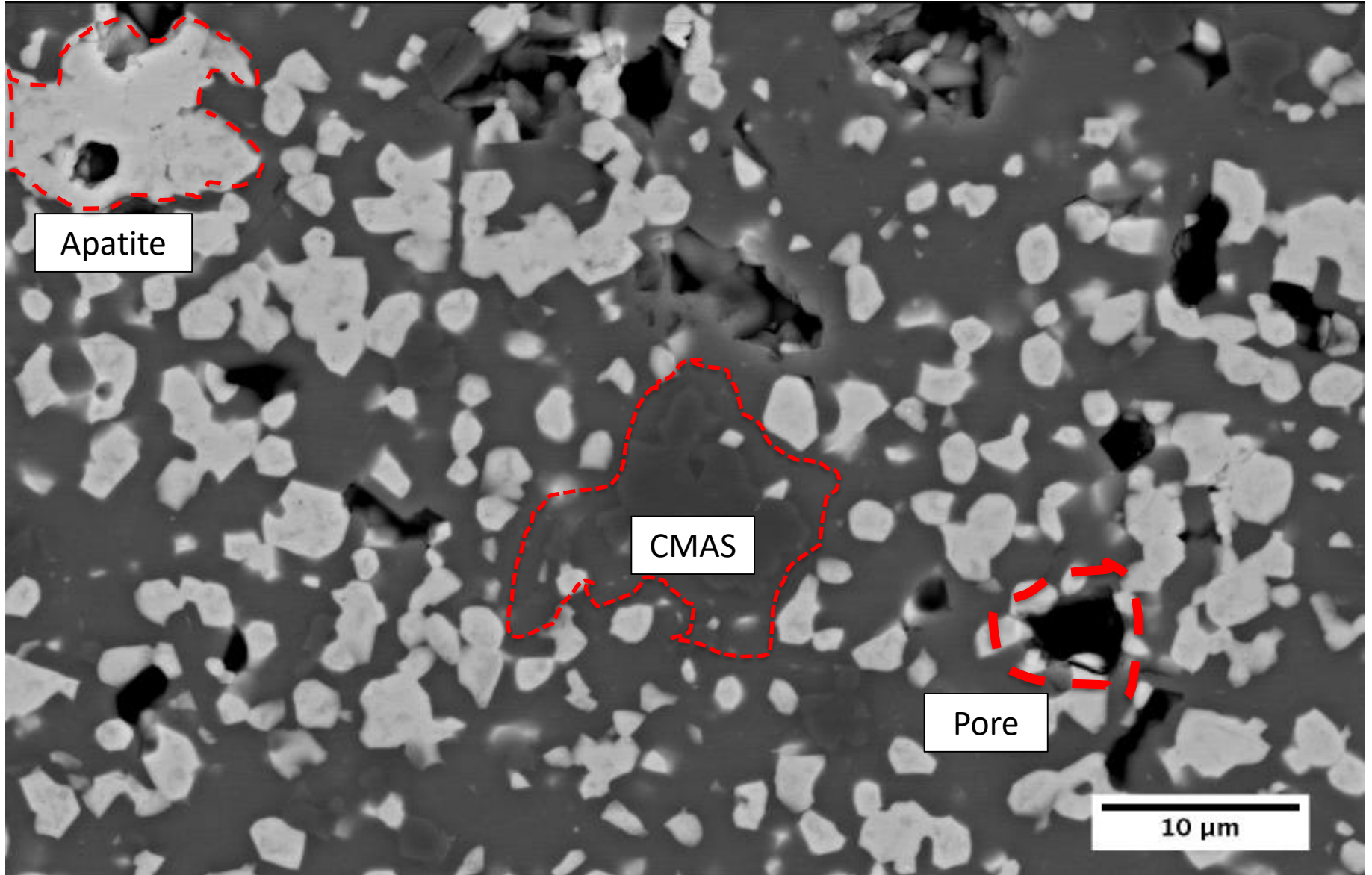
React Powders in Furnace (1300°C)



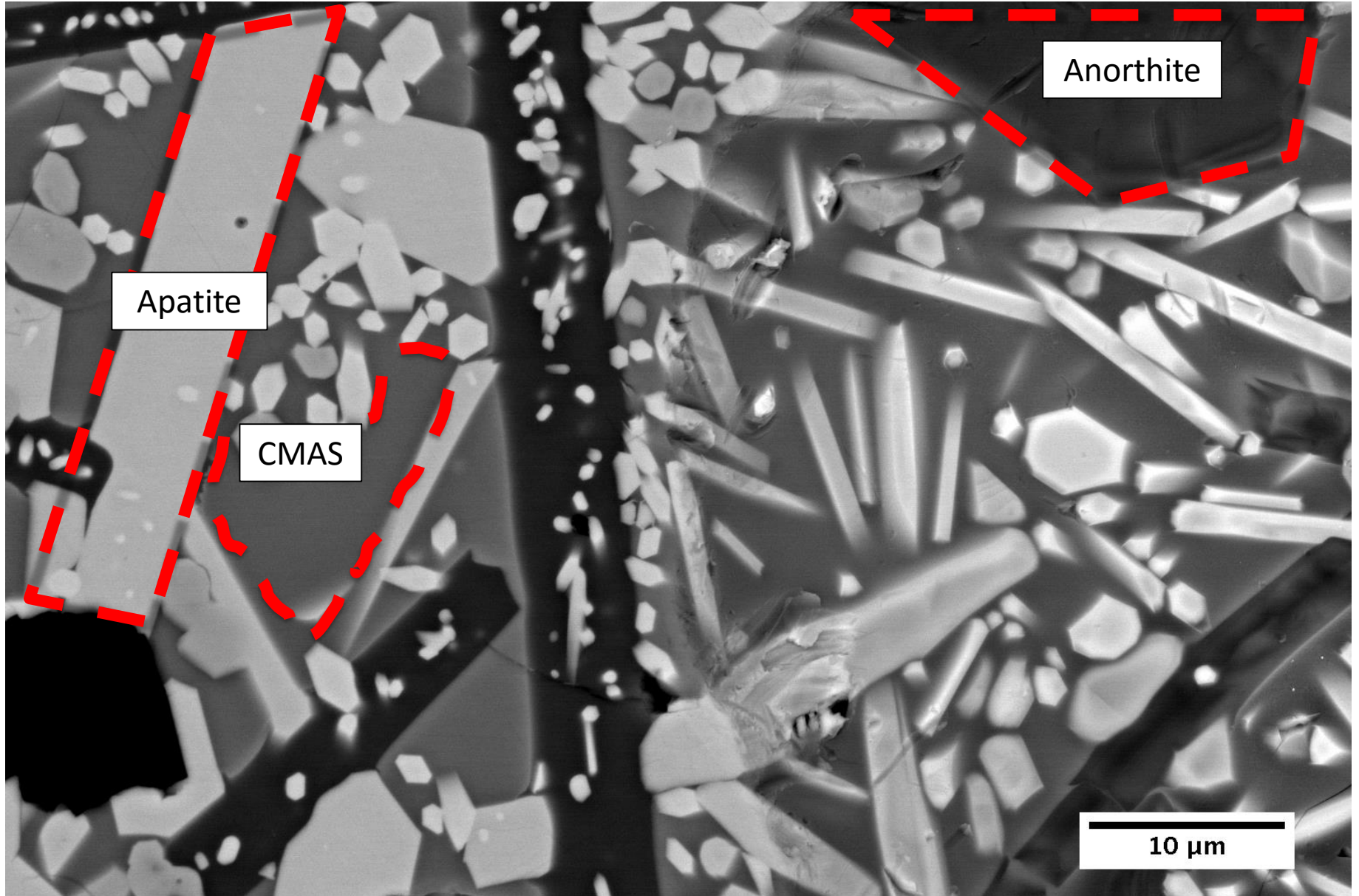
Prepare for Microscope



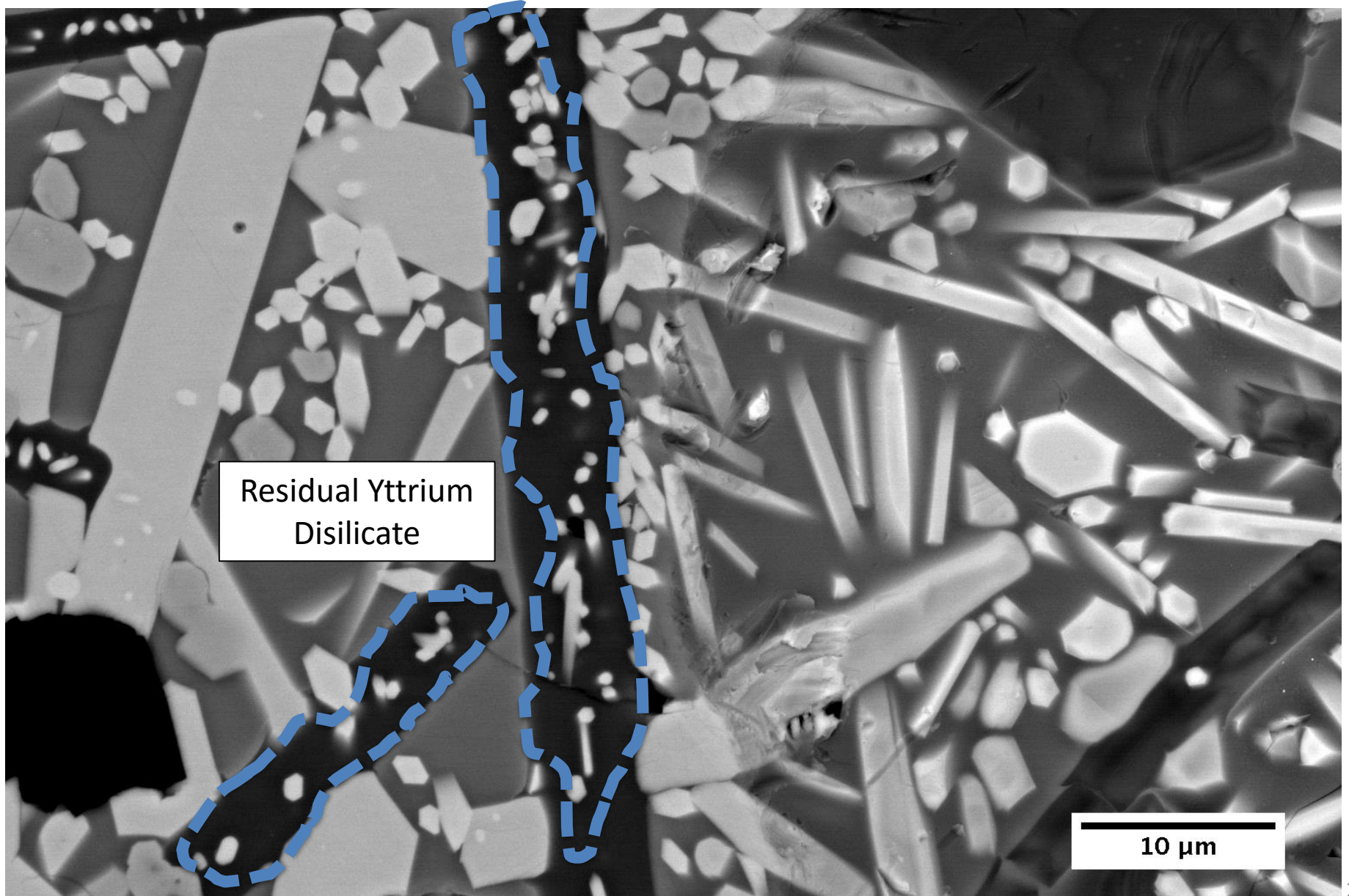
3000X Test 1 C_{31%}S_{43%} & 0.333 mol YDS



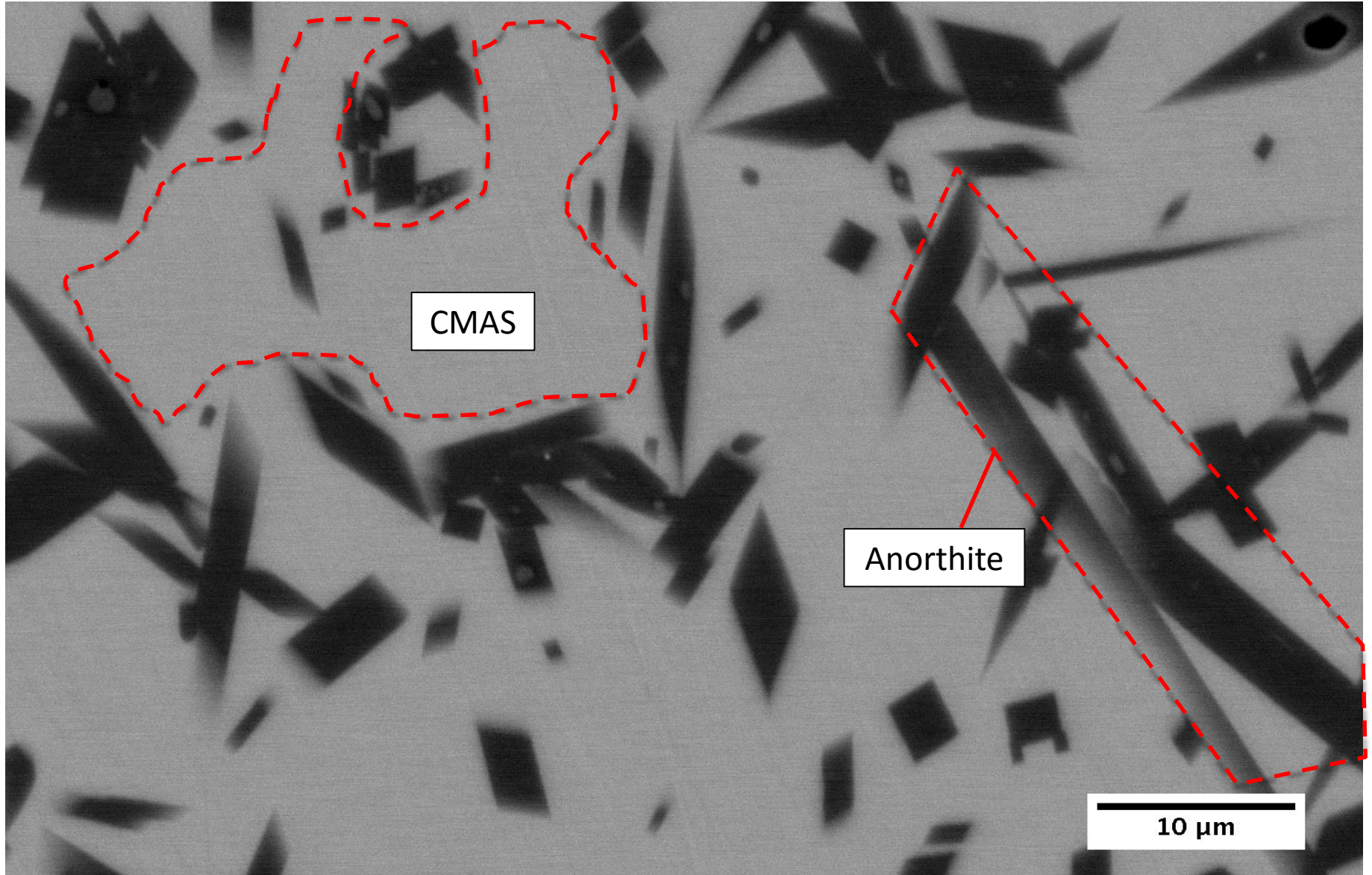
3000X Test 5 C_{31%}S_{43%} & 2.0 mol YDS



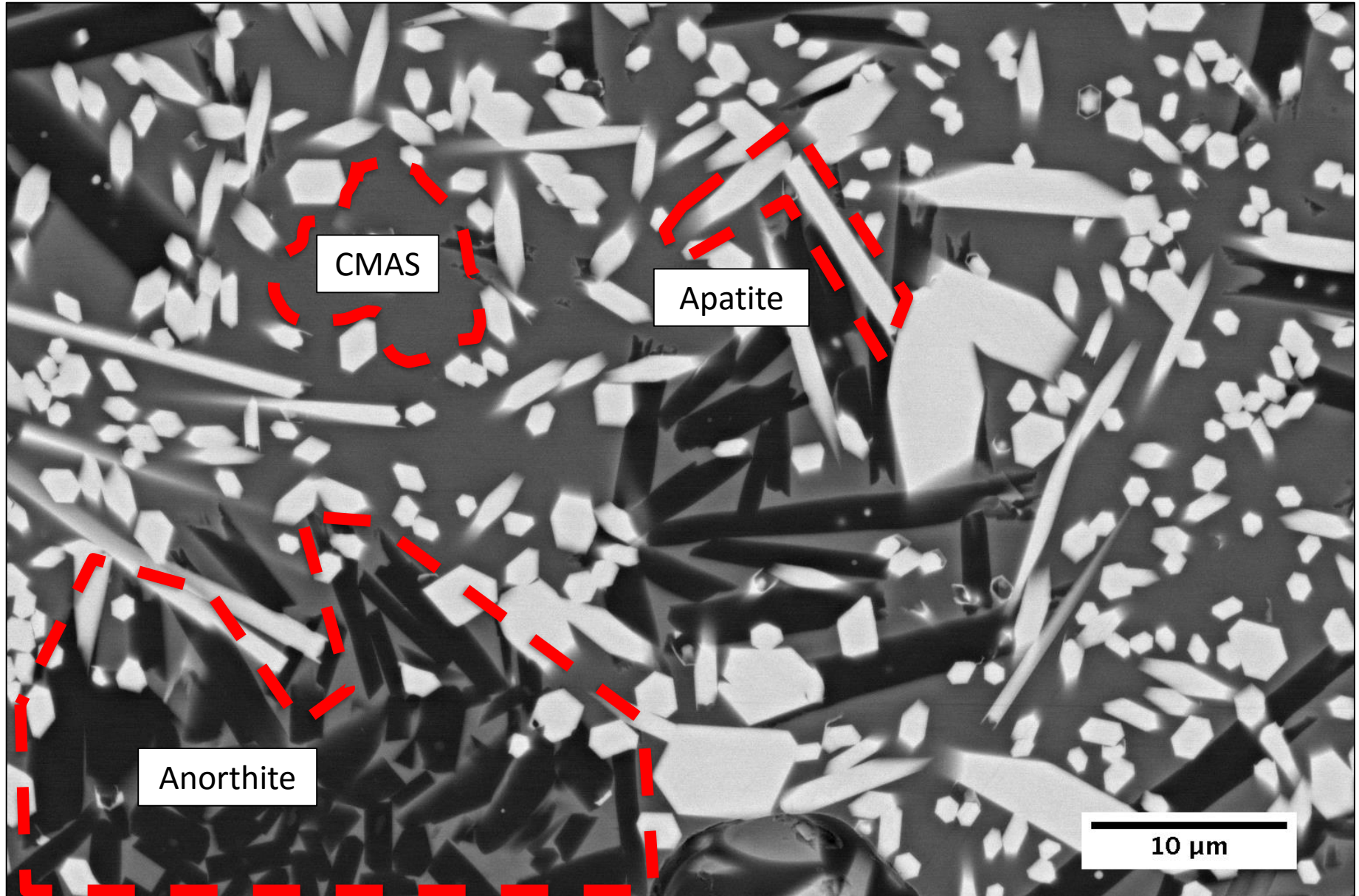
3000X Test 5 C_{31%}S_{43%} & 2.0 mol YDS



3000X Test 3 C_{10%}S_{70%} & 0.333 mol YDS



3000X Test 4 C_{31%}S_{43%} & 1.0 mol YDS



Test 3: Overall vs. Expected

	CaO	MgO	FeO _{1.5}	AlO _{1.5}	SiO ₂	YO _{1.5}
Expected	8%	4%	4%	8%	65%	12%
Measured	5%	2%	3%	37%	45%	9%
Expected - Al	8%	4%	4%		70%	14%
Measured - Al	8%	3%	4%		71%	14%

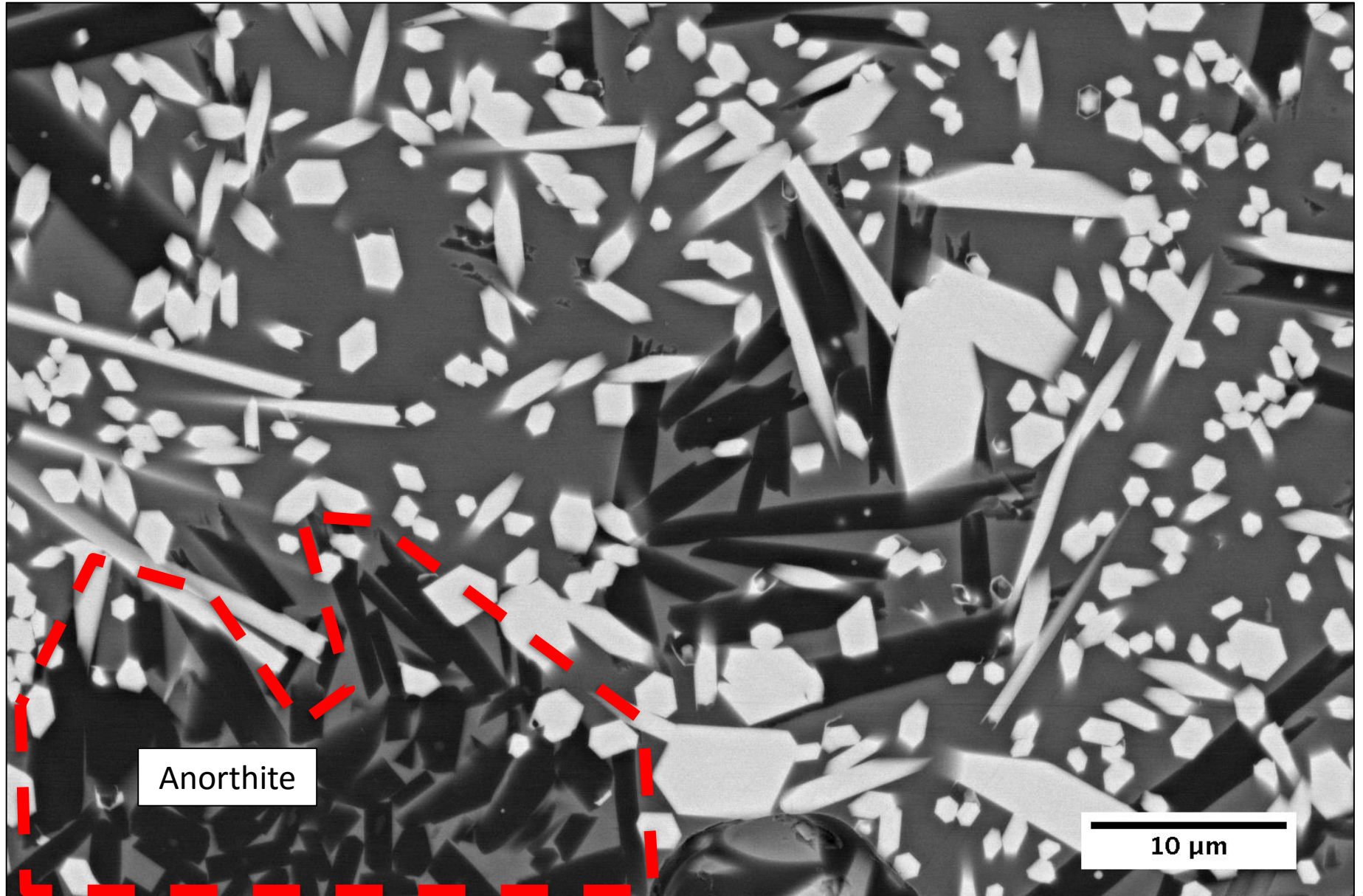
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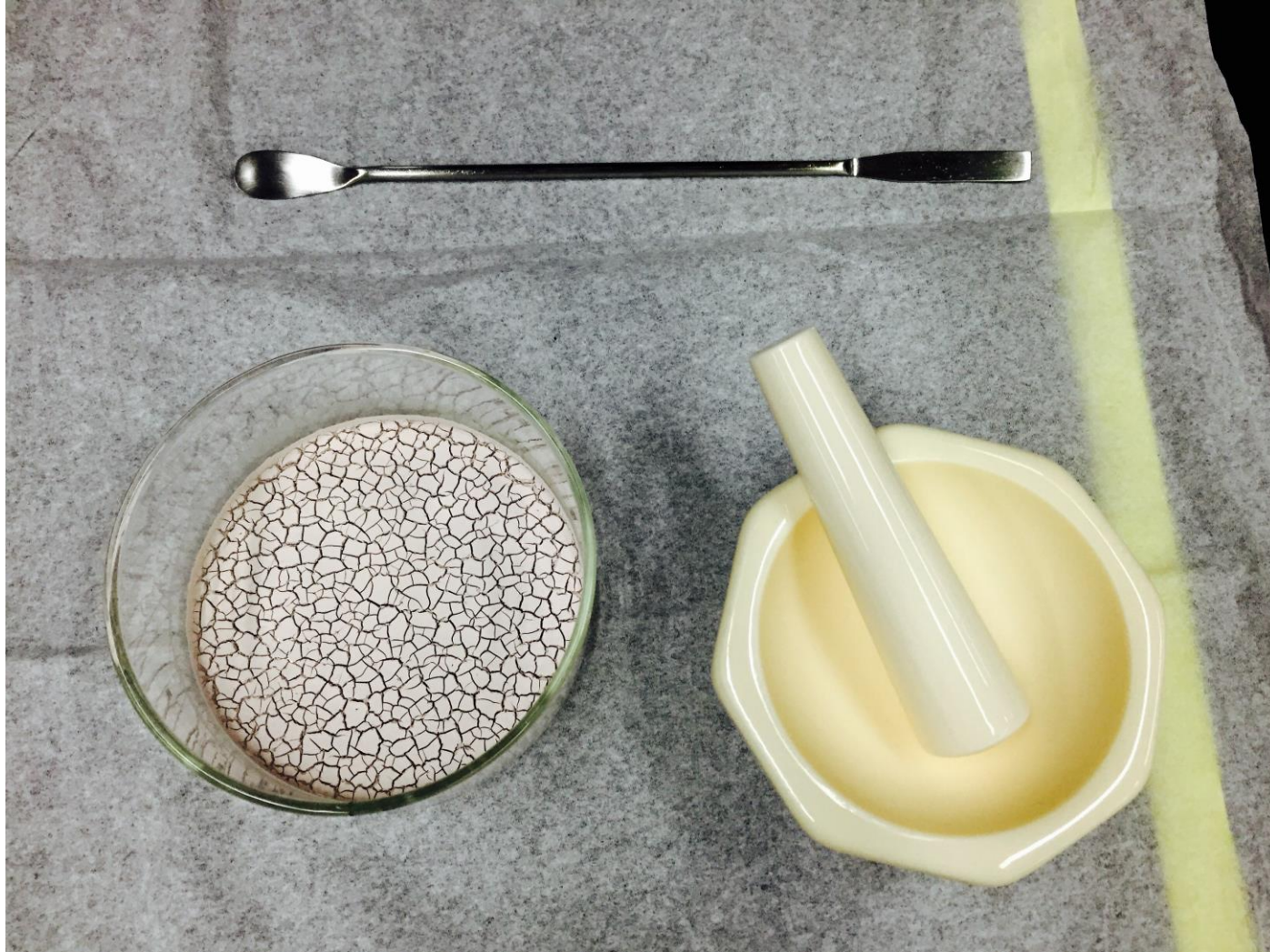
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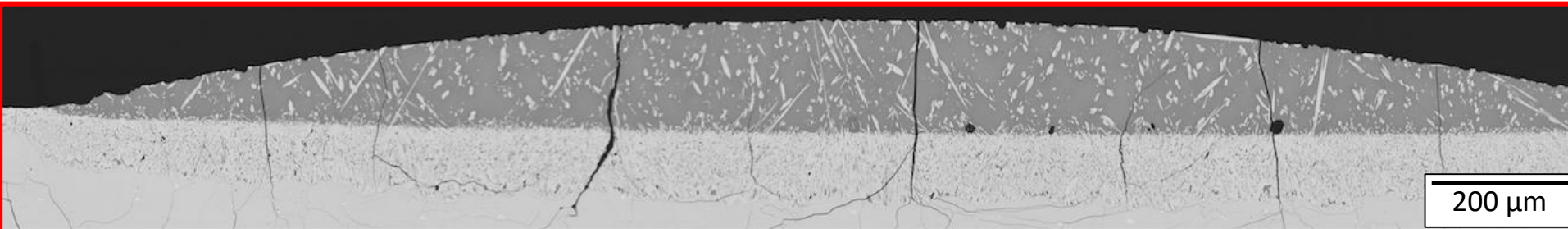
Future Recession Experiments



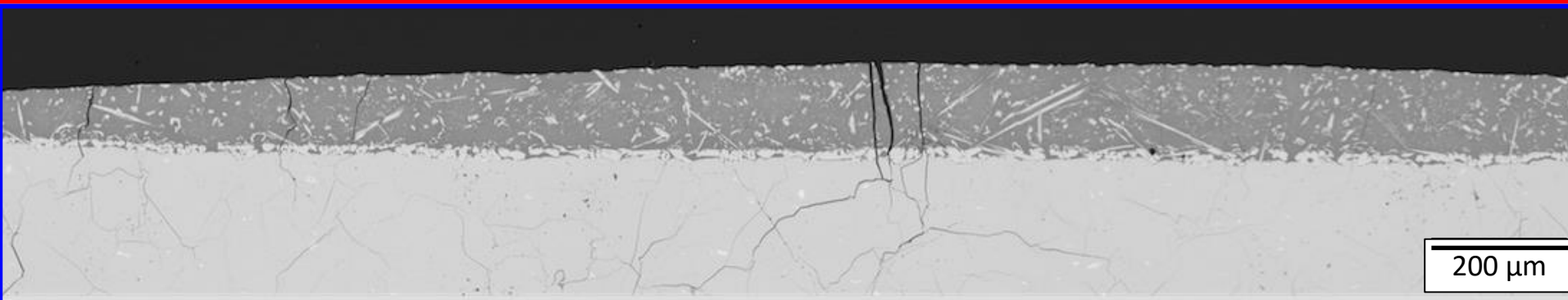
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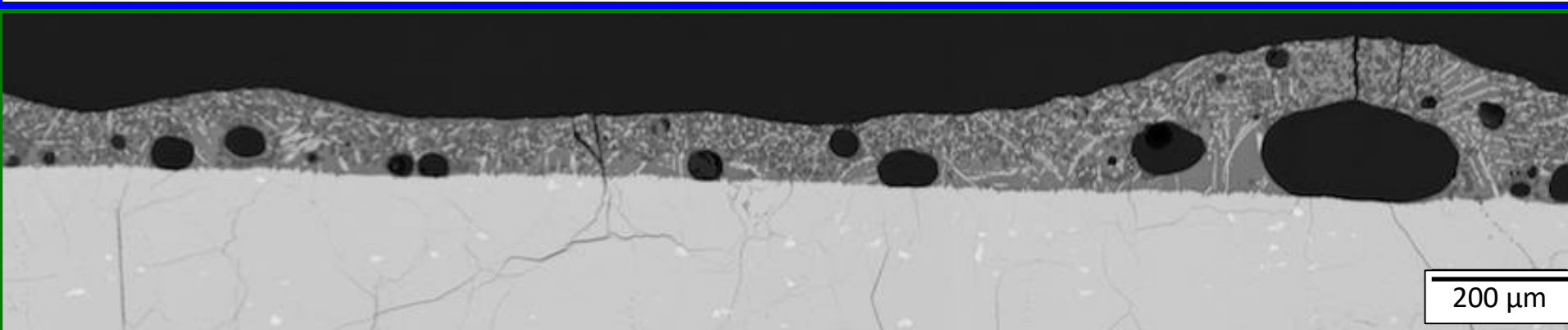
Future Recession Experiments



$(\text{CaO})_{31\%}[\dots](\text{SiO}_2)_{43\%}$ at 1400°C - 4 hours



$(\text{CaO})_{20\%}[\dots](\text{SiO}_2)_{60\%}$ at 1400°C - 4 hours



$(\text{CaO})_{10\%}[\dots](\text{SiO}_2)_{70\%}$ at 1400°C - 4 hours

Acknowledgements

William Summers

David Poerschke

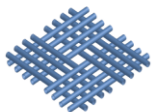
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Megan Wakefield



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