



UNIVERSITY OF  
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# Carbides for Future Fission Environments

## CaFFE

### 2018 Update

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# CAFFE Research Project: Objectives

- Develop Zr carbide based materials for high dpa operation
- MAX phase-like layered carbides - potentially machinable
- Good neutronics and resistant to radiation damage & corrosion

## MAX Phases

➤ **M = Zr**

A = Al

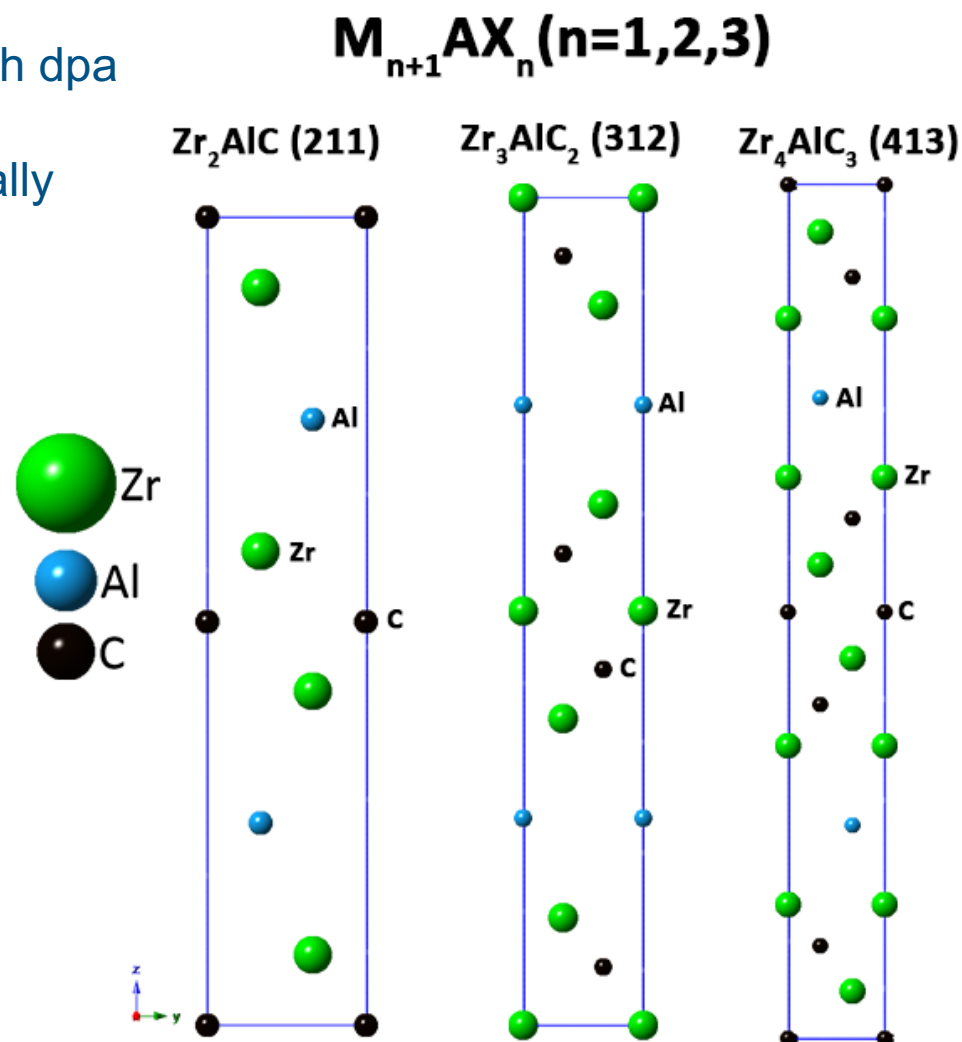
X = C

➤ **Ionic Radius**

$r_{\text{Zr}} = 0.86 \text{ \AA}$

$r_{\text{Al}} = 0.53 \text{ \AA}$

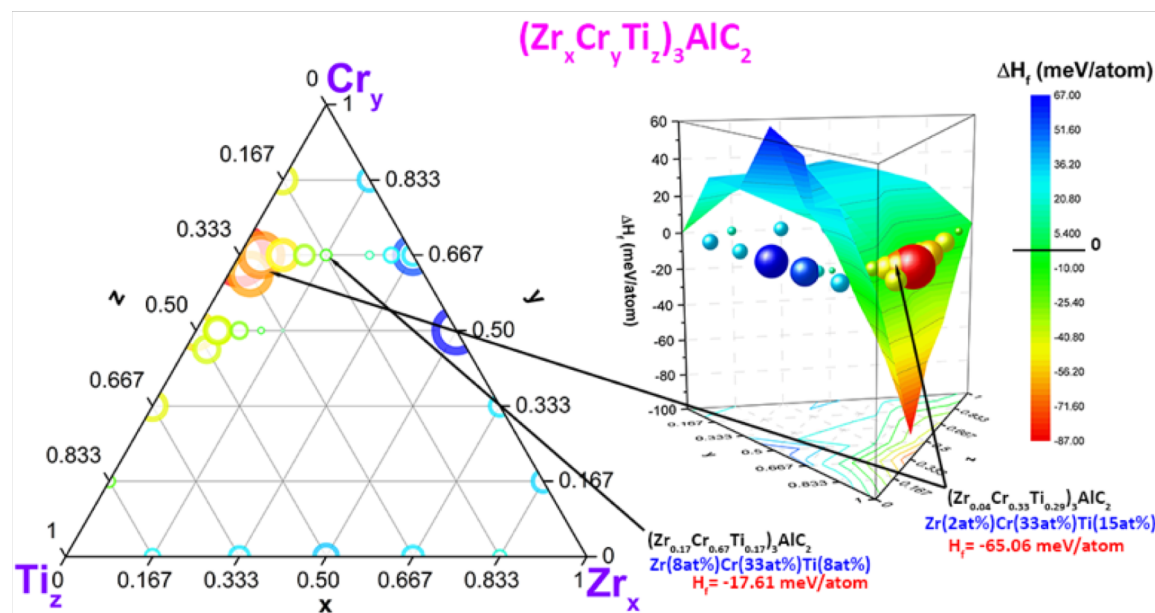
$r_{\text{C}} = 0.29 \text{ \AA}$



# CAFFE Research Project: Progress

Materials development: ~60% yields of ternary phases  
(secondary phases: ZrC and ZrAl intermetallics)  
Addition of Si, Ti, Cr to create quaternary and quinary phases increases yields to 80-90%

## Modelling



# CAFFE Research Project: Progress

## Material durability - under irradiation

Manchester DCF - Dave Bowden, Joe Ward (graduated), Phillip Frankel

0.01- 1 dpa proton (2MeV) at 350°C and 575°C

Z<sub>2</sub>AlC, Zr<sub>3</sub>AlC<sub>2</sub>, up to 1.5% anisotropic swelling under proton irradiation measured by XRD

## Material durability - in primary water

Tests on Ti-based MAX phases (primary water at 300°C) show that Al and Si do not form protective oxide coatings

Cr MAX phases show good aqueous durability.

preliminary results on Zr based MAX phases show even poorer durability than Ti based MAX phases

# CaFFE Joint Activities

EU H2020 Project '*Il Trovatore*' 2017-2022

Innovative cladding materials for advanced accident-tolerant energy systems

Joint meeting with CaFFE held in Manchester 19-21 March 2018



# Future activities

End of Programme Meeting  
Advanced Accident and Radiation-Tolerant Materials  
Queens' College Cambridge 24<sup>th</sup> – 26<sup>th</sup> March 2019

<https://onlinesales.admin.cam.ac.uk/conferences-and-events/earth-sciences/advanced-accident-and-radiationtolerant-materials>



## Confirmed speakers

Michel Barsoum (Drexel)  
Lance Snead (SUNY)  
Jingyang Wang (Shenyen)  
Mike Finnis (Imperial)  
Ed Lahoda (Westinghouse)  
Lumin Wang (Michigan)  
Simon Middleburgh (Bangor)

USDoE CARAT meeting follows on 27-28 March