EMA5001 Lecture 24
Transformation Kinetics for SiC Formation
Kinetics for the Formation of Nano SiC via Carbothermal Reduction Reaction

- Overall Reaction: \( \text{SiO}_2 + 3\text{C} = \text{SiC} + 2\text{CO} \)

Nano-scale SiO\(_2\)-C Mixture

\[ \text{SiO}_2(s) + \text{C}(s) = \text{SiO}(g) + \text{CO}(g) \]

\[ \text{SiO}(g) + 2\text{C}(s) = \text{SiC}(s) + \text{CO}(g) \]

Cheng, Z., MS Thesis, 2004
Confirmation of SiO & the Two-Step Reaction

EDX

XRD of Vapor Deposits

SiO = Si + SiO₂

Cheng, Z., MS Thesis, 2004
Reaction Kinetics from Weight Change

- Best fit to Interface-controlled “Grow in”/”Shrinking Core” model

Weight Loss Data

Fitting to Interface-controlled “shrinking-core” model

Cheng, Z., MS Thesis, 2004
Good fit also to Nucleation – Growth model

Nucleation – Growth Model

Diffusion-Controlled “Grow In” Model – Jander’s Equation

Also good fit, $n = 1$

$\times$ Site saturation, 1D growth
✓ Constant nucleation - no growth

Cheng, Z., MS Thesis, 2004
Microstructure Changes to Confirm Reaction Model

Essentially very small growth of SiC crystallites during CTR reaction at intermediate range

Growth of porosity matching expectation

Cheng, Z., MS Thesis, 2004
Rate-Limiting Step & Activation Energy

- Reaction is limited by sub-step of 
  \[ \text{SiO} + \text{C} = \text{SiC} + 2\text{CO} \]
  For the following reasons
  - Always have SiO formation
  - Shape of SiC dependent largely on C size and not SiO$_2$ size

Cheng, Z., MS Thesis, 2004
Little grain growth during reaction

BEFORE Reaction

$\theta = 70.5^\circ$

$\bar{d} = 0.20\,\text{nm}$

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$\bar{d} = 2.5\,\text{nm}$

$\bar{d} = 1\,\text{nm}$

$\bar{d} = 10\,\text{nm}$

$f = 35\%$

$f = 63\%$

 Cheng, Z., MS Thesis, 2004

Transform Kinetics – SiC Formation

Zhe Cheng (2016)
$f = 0\%$
Almost fully dense

$\ f = 95\%$
Highly porous