



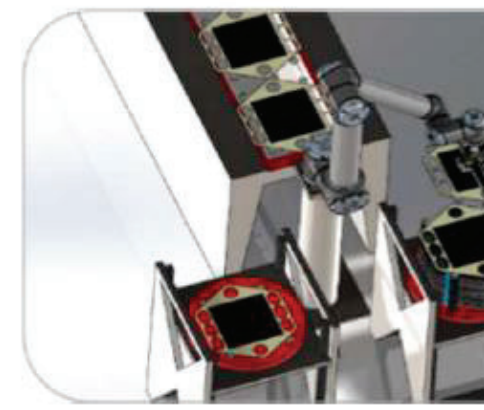
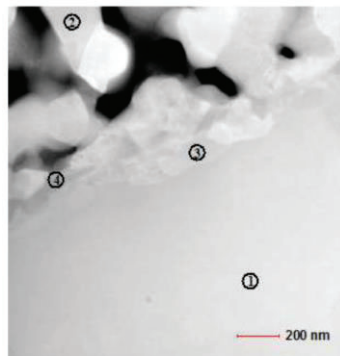
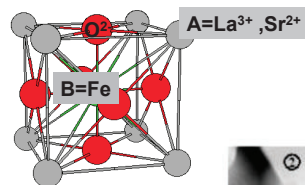
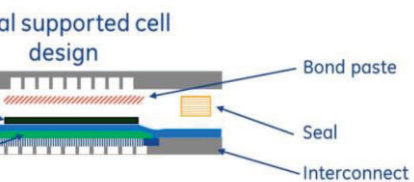
Cummins Solid Oxide Electrolyte Manufacturing

Todd Striker

March 8, 2022

Public

ummins SOEC manufacturing evolution



2002-2007
Process / Thermal Spray
proof of concept

2008-2013
Preventing Materials
Degradation; Materials set
down-select

2014-2019
Cell & Stack Development

2020-2022
High-Volume Prototyping

ummins I4.0 Initiative



1780

1.0

Production is mechanized by water and steam power



1870

2.0

Introduction of electricity led to the assembly line and mass production



1970

3.0

Automation is fueled by computers and electronics



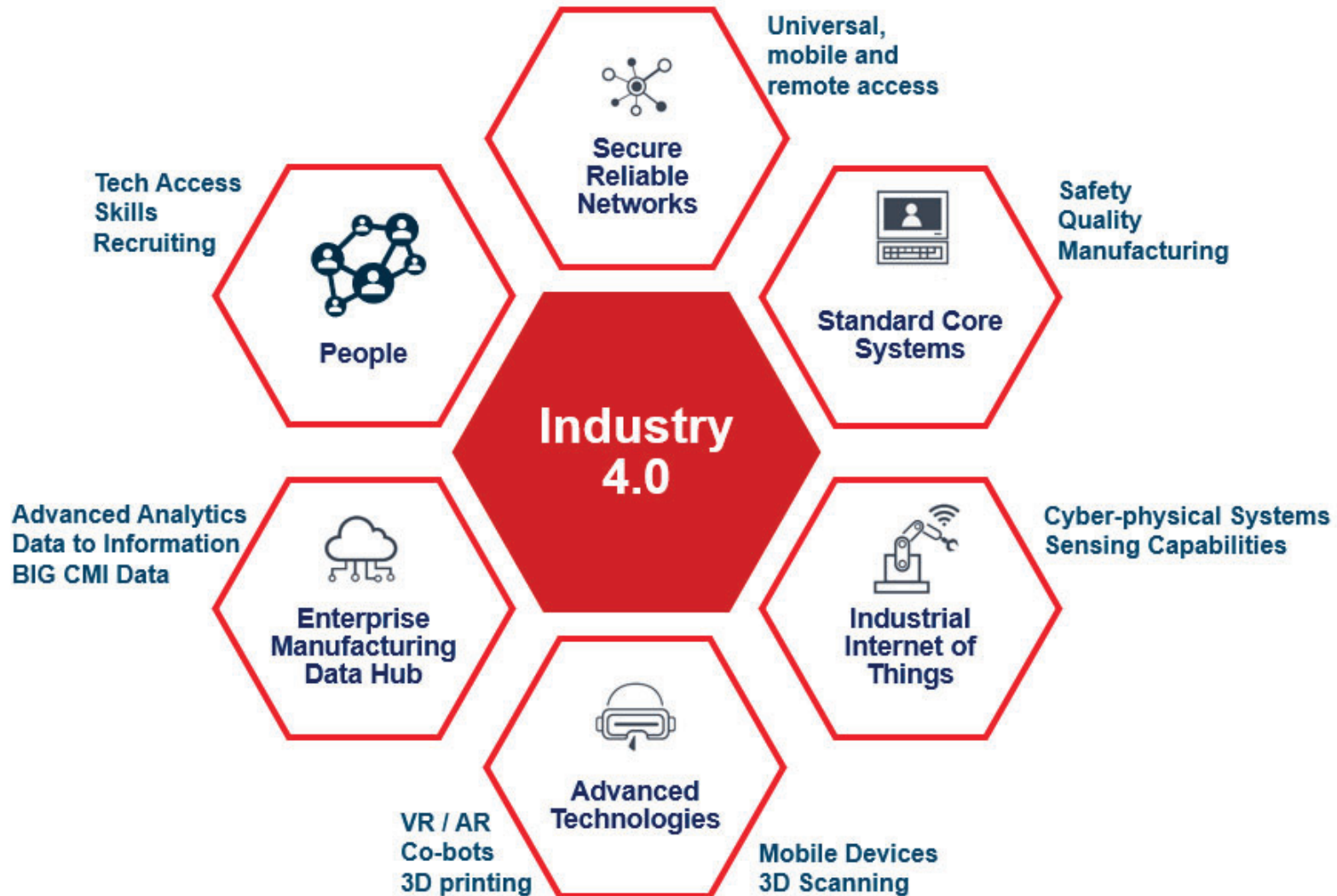
TODAY

4.0

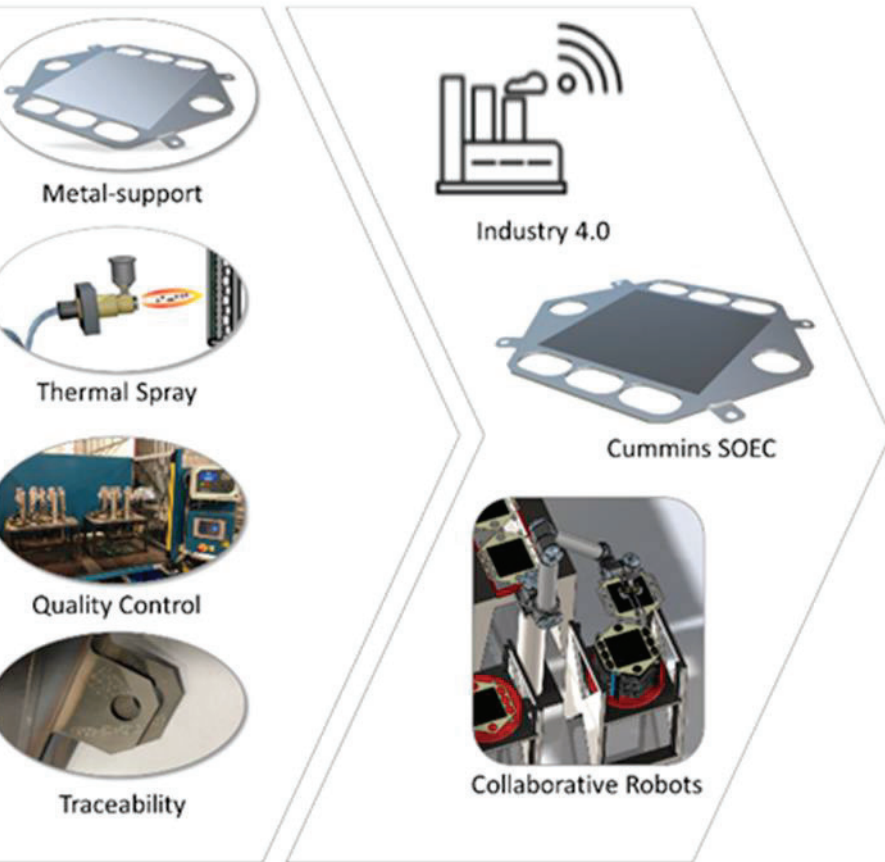
Advanced technology and Internet of Things powering connectivity, data and cyber physical systems

More holistic, productive, better connected ecosystem

4.0 Elements



Cell and Stack Manufacturing



Key Enablers

Metal-support is durable

Additive approach is sequential

Quality control is fast and non-destructive

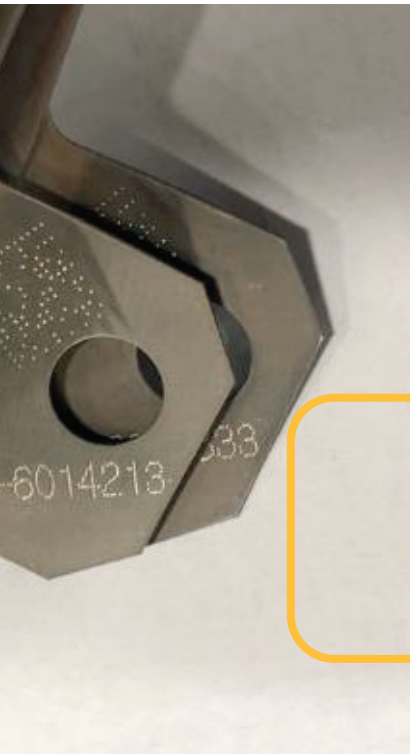
All cells are traceable

Key Initiatives

Design for I4.0 technology early

Leverage collaborative robots for flexibility

ion & QC



Quality Control



Printing



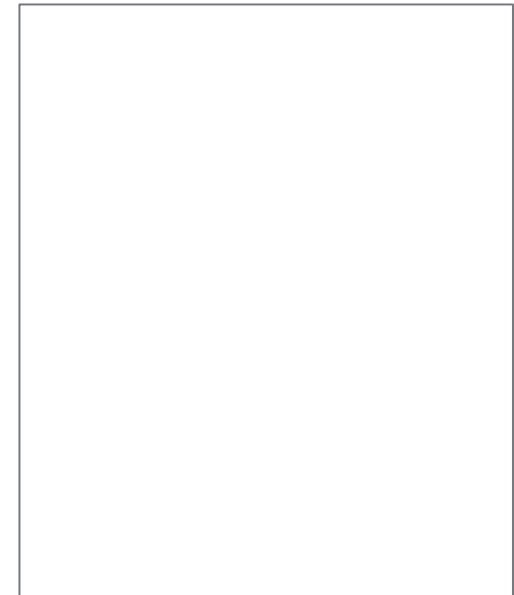
Stacking



Quality Control is a major emphasis

- Traceability of parts will be very important
 - 100% inspection
 - 100% read rate
 - 100% identification of defects
 - 100% removal of defects before stacking
 - Thickness
 - Uniformity (vision) – machine learning
 - Braze quality
 - Contaminants
- Root cause analysis

Traceability



- Exploring mechanical and laser marking
- Challenge is readability after treatments

Thoughts / Challenges

- Traceability
 - 100% reliability required
 - Bar codes that are durable through manufacturing, heat treatment, and operation
- Integration
 - SCADA systems & standardization across equipment
 - Line balancing for continuous processes
 - Buffering, queuing
- Material handling
 - Leverage existing knowledge
 - SMT / PCB
 - Semiconductors
- Large format industrial screen printers
- Cost effective equipment and integrators

