Natural Resources Canada | Ressources naturelles Canada

Catalyzing Clean Energy Solutions for All [1.]

1. http://mission-innovation.net/

Mark S Kozdras, NRCan

EMIRI: Re-Inventing Materials Research

30 June 2022, Grenoble

Canada

- Launched during COP21 under the UN FCCC, 2015
- Global initiative to accelerate the urgent transition to a low-carbon economy by focusing on RD&D in eight technology areas or Innovation Challenges
  - e.g. Clean Energy Materials, IC6
- Double annual national clean energy R&D investment by 2021: 15 > 30 B USD
- June 2021, MI2.0 launched a ‘decade of clean energy innovation’
  - Missions, e.g. Clean Hydrogen (2 USD/kg) and Carbon Dioxide Removal

MI Materials For Energy (IC6-M4E)

- The IC6-M4E network is accelerating materials innovation via a platform technology, MAPs[1]
- MAPs are under development or operation for various applications:
  e.g. batteries, solar cells, organic lasers, H_2 production and CO_2 conversion
- MAPs are materials agnostic and can democratize materials discovery and development
- MAPs includes infrastructure and expertise to accelerate innovation for Mission-critical materials and devices:
  e.g. batteries (BIG-MAP), OPV (HI-ERN AMANDA, UBC Project Ada)

BIG-MAP

HI ERN Helmholtz Institute Erlangen-Nürnberg

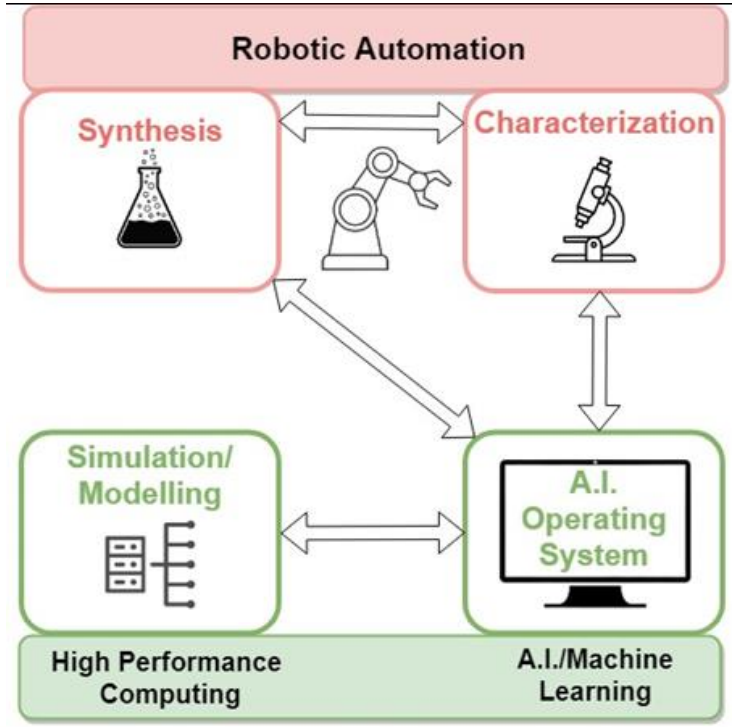
Ada

1. Materials Acceleration Platforms

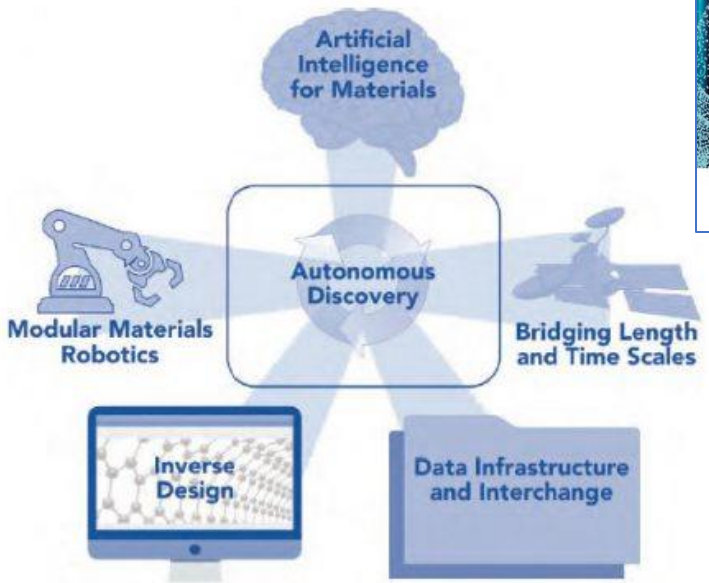
Materials Acceleration Platforms
Self-Driving/Autonomous Materials Laboratories

MISSION INNOVATION

Acceleration >10x ↑



- Closed-loop synthesis, characterization and computation
- Smart robotic automation
- Accelerated experimental planning and simulation/modeling through artificial intelligence (machine learning)
- Develop novel materials and devices



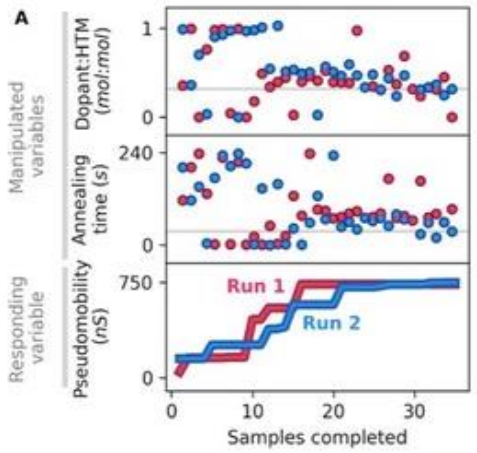
MAP report, Jan 2018

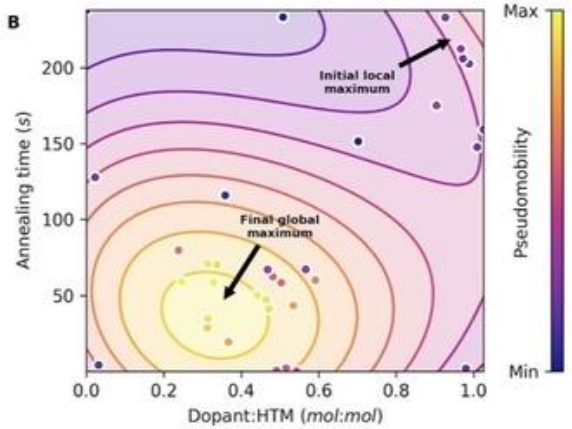
The Urgent Need for Acceleration
Why Now?

- Climate change
  - Unprecedented climate challenges
  - Escalating rate of change
  - Myriad solution pathways needed
- Materials supply chains
  - Critical material vulnerability, e.g. geopolitics
  - Depleting amounts / quality of mineral deposits
  - 50-80% of the cost of clean energy is materials
- MAP technology is here
  - AI, automation, computation/modeling
  - Rapid experimental verification

Concept to Demonstration
What next?

- Simultaneous platform development
  - Data ontologies, architectures, structures
  - ML techniques to enable and accelerate:
    - Modeling and simulation
    - Big data, metadata
    - Experimental planning
  - Automation:
    - Effective coupling of synthesis and characterization
- Platform implementation
  - Consistent workflow development
  - Consistent MAP design approach and data curation
  - Diverse MAP architectures, sensible replication
  - Multidisciplinary skill development





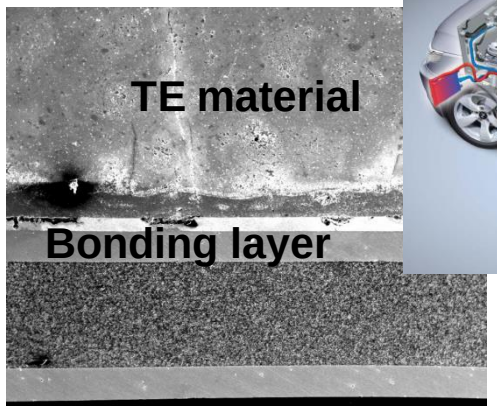
UBC BERLINGUETTE RESEARCH HEIN LAB

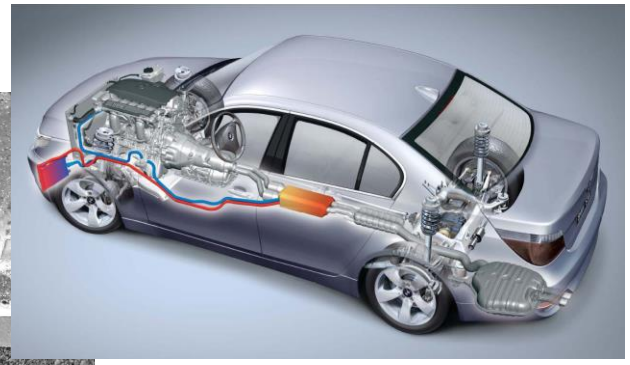
http://www.projectada.ca/

Materials to Devices…
… Including process development and scaling

- Existing device level systems
  - HI-ERN AMANDA
  - KIT-Ulm BIG-MAP

- Device level systems in progress
  - NRCan TEG-MAP (thermoelectrics)





Thermoelectric Materials
NRCan TEG-MAP

Canadian MAP topics
What else?

Active developments

- University of British Columbia
  - Project Ada, liquid handling: **OPV hole transport materials**, membrane electrode assemblies for CO_2 conversion
  - Telescope (spin-off), process chemistry: Lithium from brine solutions
- University of Toronto:
  - Liquid handling: **Organic lasers**, Redox flow batteries
  - Thin Film PVD: High Entropy Alloys
- NRCan / National Research Council:
  - High temperature melt/solidify/ heat treatment: **Thermoelectrics**, Al.Sc wire, High Entropy Alloys
  - Electrocatalysis: **H_2 production, CO_2 conversion**
  - Electrochemistry: **Corrosion**, Electroplating

Other ideas under development

- Thermal Energy Storage: Phase change and thermochemical materials (MI IC7)
- Metal Joining: Soldering/brazing systems
- Mining Floatation: Ore refinement
- Metal 3D Printing: Metal powder bed, spray and wire
- Cement and concrete
- Biomaterials / Biomedical

***bold: collaboration with euro partner**

Building from IC6
MAPs: What's needed?

- Ideation
  - White paper solicitation: e.g. MAP call[1.] in Matter[2.]
  - Conference / workshop: e.g. Acceleration Consortium[3.], GC-MAC[4.]
  - Exchanges, training: e.g. GC-MAC[4.], StoRIES[5.]
- Wider MAP communication and coordination
  - Increased horizontal engagement of academic and industrial researchers – build the base, engage end-use applications
- Increased coordination and implementation
  - Workflow concept development and review, esp. industry
  - Data ontologies, architectures and curation
  - Deploy more MAPs for diverse applications

1. https://doi.org/10.1016/j.matt.2022.05.035
2. https://www.cell.com/matter/home
3. https://acceleration.utoronto.ca/
4. https://gcmac.ca/
5. https://eera-energystorage.eu

Achieving Impact
What's needed?

- Acceleration infrastructure:
  e.g. Canada's Centre for Accelerated Materials and Discovery, *CAMDI*
  - $60M expansion, design-built for MAPs
- Industry alignment and engagement
  e.g. EMIRI, EurA AG
  - SMEs and multinationals

- Funding coordination and leveraging
  - Increased international collaboration and cooperation
  - Top down engagement of science based departments and agencies
    - Early integration in policy setting and deployment, especially as a cross-cutting sub-task
  - Coordination support as a multinational / multidisciplinary initiative

Accelerated Materials Discovery…

- Success is:
  - Advanced materials and devices are available for commercialization and scale-up
- Achieved by
  - Wide-spread MAP implementation and coordination
  - Strong industry cooperation and technology pull
  - International collaboration, exchange and training
  - Early integration of materials and accelerated discovery in policy development and deployment
  - Support actions and support for:
    - Collaboration building
    - MAP deployment and operation
    - Industry engagement

Thank you

mark.kozdras@nrcan.gc.ca