EERA
European Energy Research Alliance

AMPEA Advanced Materials and Processes for Energy Applications

Innovative high temperature material concepts drive clean energy technologies forward

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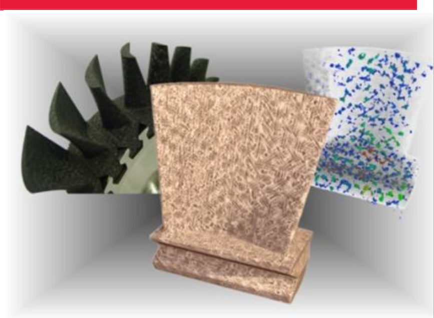
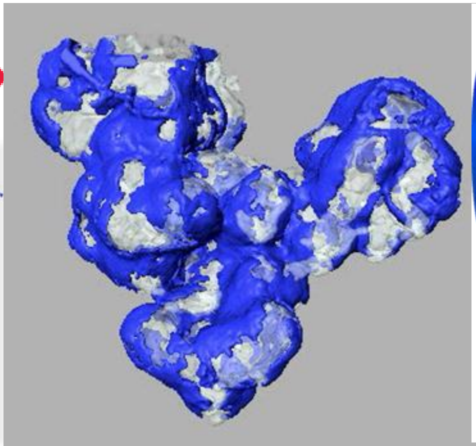
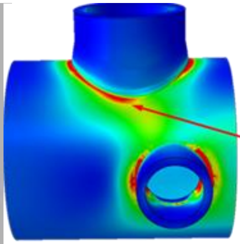
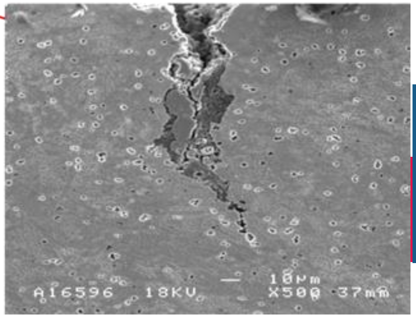
WS “Materials resistant to extreme conditions for future energy systems",
12-14.06.2017, Kyiv, Ukraine

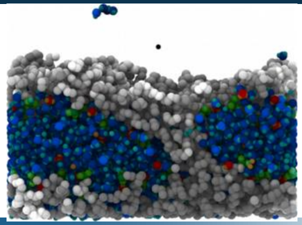
www.eera-set.eu











EERA is an official part of the EU SET-Plan.

http://setis.ec.europa.eu/

FUTURE CHALLENGE

- The transition to a low carbon future is a big challenge, which requires innovative technologies, materials and systems.

EERA-JP AMPEA "Advanced Materials and Processes for Energy Applications"

- Aim is to foster a multi-disciplinary approach to develop enabling tools and new concepts for future emerging energy technologies.
- The main objective is to harness and integrate materials science and process innovation for high performance sustainable energy technologies, in order to enhance the long-term competitiveness of European Industry.

AMPEA JP

Matrix SP structure involving:

- "***Tools***" sub-programmes (SPs)

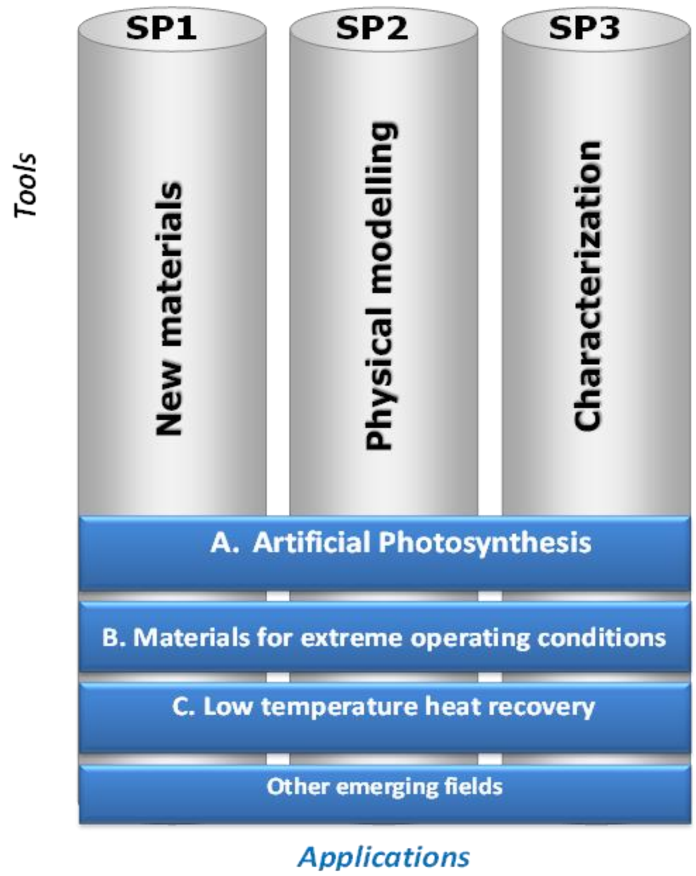
  → Generic research areas

- "***Applications***" transversal SPs

➢ Coordinate and promote multidisciplinary joint research in **basic science for energy** (**materials** and **processes**)

➢ TRL 1 → 4

➢ Future emerging energy technologies and established ones (other JPs) where materials issues are involved



AMPEA JP

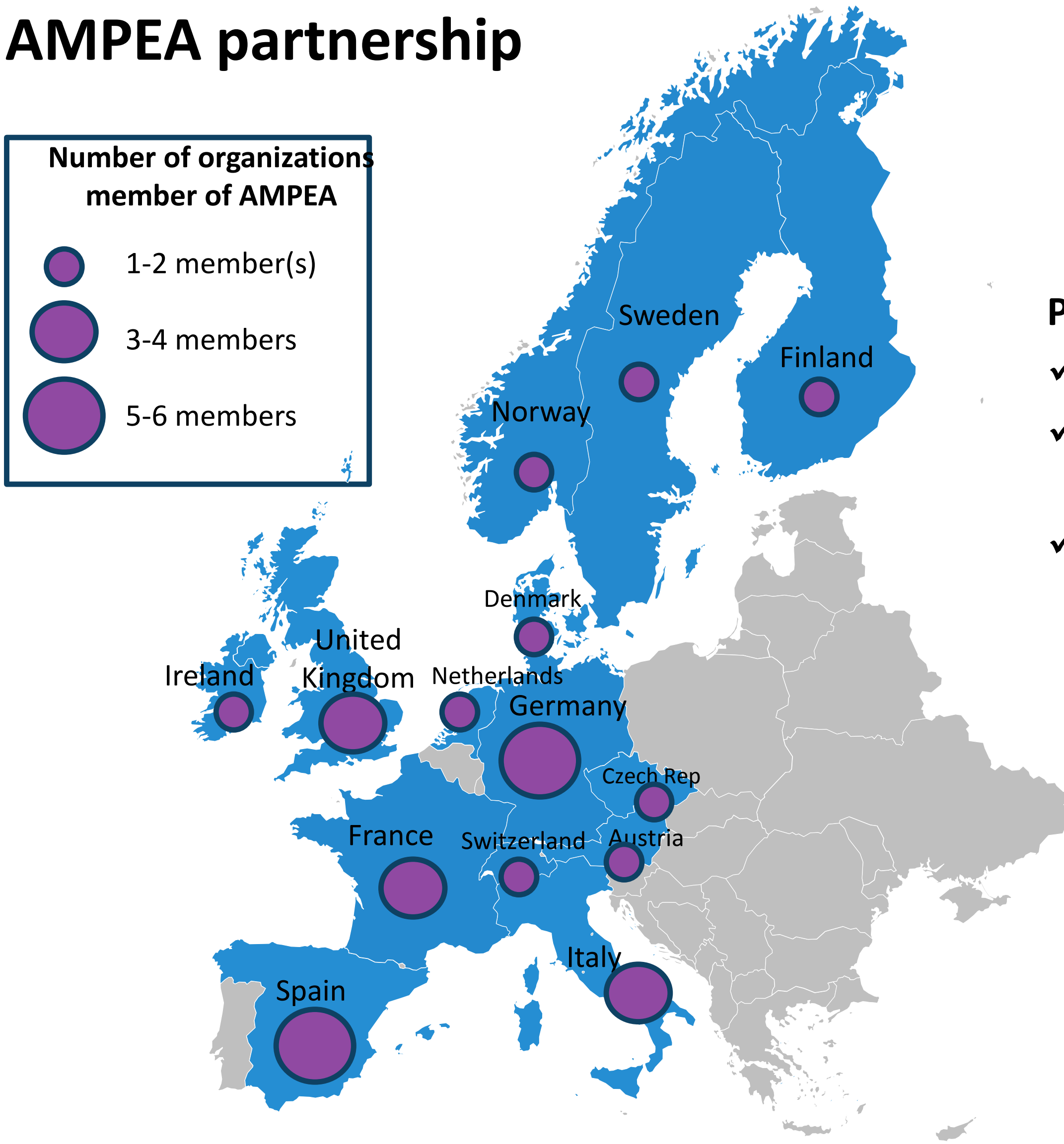
Joint Programme Steering Committee — All Participants

Joint Programme Management Board — Joint Programme Coordinator CEA (Fr.) + Subprogramme Coordinators

SP1: New materials	SP2: Physical modelling	SP3: Characterization	SPA Artificial photosynthesis	SPB: Materials for extreme operating conditions	SPC: Low temperature heat recovery
FZ Jülich (Germ.) CSIC (Sp.)	UKERC (UK) Lorraine Univ. (Fr.)	FZ Jülich (Germ.) ENEA (It.)	HZB (Germ.) CEA (Fr.)	VTT (Fin.) DLR (Germ.)	Polito (It.) CNR (It.)

Sub-programmes (SPs)
1 SP coordinator, 1 deputy

AMPEA partnership



Present status:

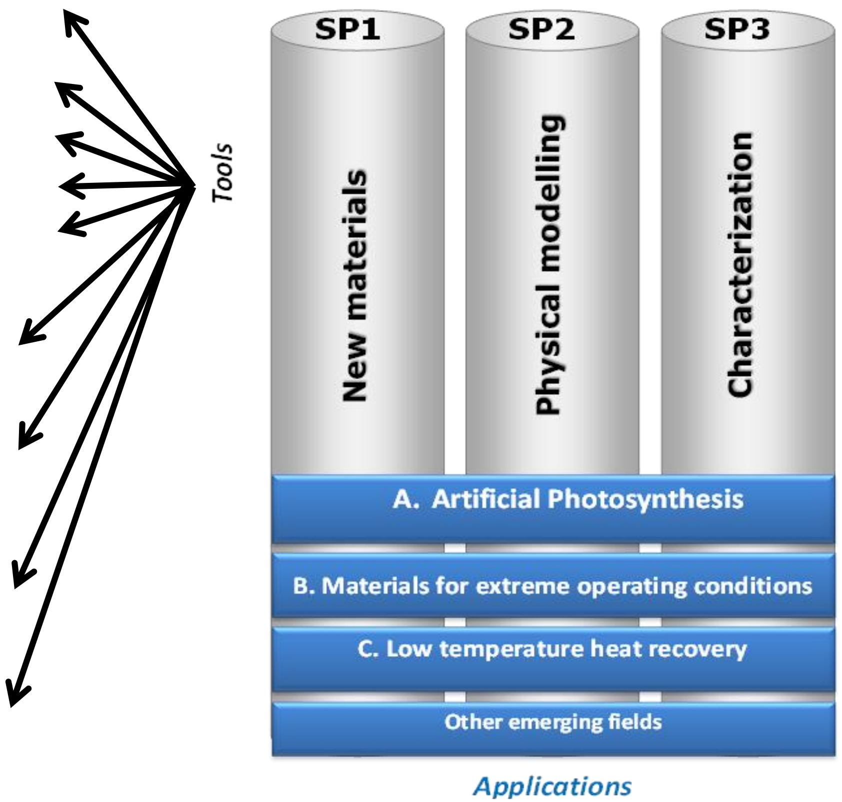
- ✓ 14 countries
- ✓ 32 organizations including 3 associate members
- ✓ Pending applications

AMPEA vs other EERA JPs

AMPEA vs other EERA JPs

- Two materials oriented EERA JPs: **AMPEA** and **Nuclear Materials**
- Cross-fertilization between "*Tools*" AMPEA SPs and other JPs

  - **Bioenergy**
  - **Carbon capture and storage**
  - **Concentrated Solar Power**
  - **Energy Storage**
  - **Fuel cells and hydrogen**
  - Geothermal
  - **Nuclear materials**
  - Ocean Energy
  - **Photovoltaic**
  - Shale gas
  - **Smart cities**
  - Smart grids
  - **Wind energy**
  - **Societal challenges**



Strategy of AMPEA to be connected to a forum of industrials in the field of materials for energy rather than to a few industrials

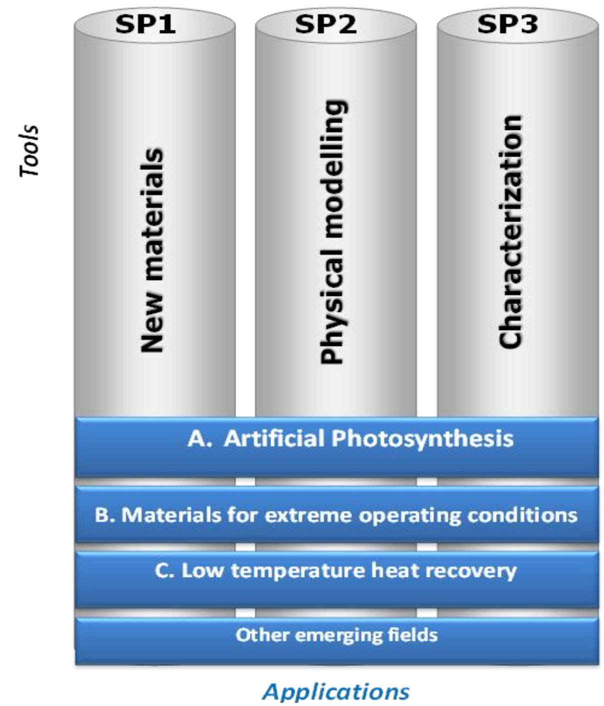
EMIRI

Energy Materials Industrial Research Initiative

Managing director:

Dr Fabrice Stassin

www.emiri.eu



Some EMIRI members

- **Industry partners**:

3M, AGC, ArcelorMittal, BEKAERT better together, BOSCH Invented for life, DOW CORNING, H.C.Starck, Heraeus, LABORELEC GDF SUEZ, PLANSEE, SAFT, SIEMENS, SOLVAY, umicore, voestalpine ONE STEP AHEAD.

- **Research and Technology Organizations (RTOs)**:

cea, IK4 CIDETEC, Cranfield University, DTU, ECN, imec, rtmo Materials Technology, JÜLICH, Leuven, Steinbeis Advanced Risk Technologies, SINTEF, tecnalia Inspiring Business, Tekniker, TNO, UNINOVA, VTT, Université de Liège

AMPEA

Connections between AMPEA and EMIRI RTO members fosters interactions

Ways of working - Workshops coupled with JPSCs or separate events on a topic in line with the host interests and the AMPEA DoW and strategy

→ Wide dissemination within AMPEA and EERA

→ Forum for networking with potential partners, prepare proposals to calls and propositions of calls for future WPs

Some examples

- **Uppsala University**, Oct. 2013 → **Artificial photosynthesis (SPA)**
- **Forschung Zentrum Jülich**, May 2014 → **Workshop on materials for energy devices**
- **Polytechnic University of Valencia**, Nov. 2014 → **Materials for energy devices**
- **University College London**, Jun 2015 → **Modelling and characterization and energy materials and processes**
- **Politecnico di Torino**, Nov. 2015 → **Materials for low temperature heat recovery**
- **Lorraine University, Nancy**, June 2016 → **From power to chemicals**

Innovative high temperature material concepts

Emerging energy technologies require materials with a combination of properties such as

- ❑ High thermal stability
- ❑ Resistance against corrosion, erosion, abrasion
- ❑ Sufficient strength and creep resistance at extreme temperatures
- ❑ Thermomechanical stability
- ❑ Specific thermal conductivity
- ❑ Plus cost effectiveness

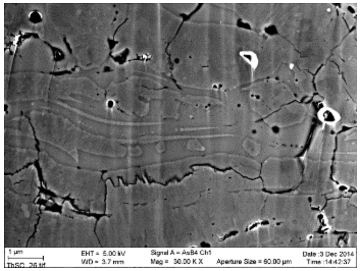
➢ In future process temperatures are expected to increase further for significant increase of Carnot-based efficiency

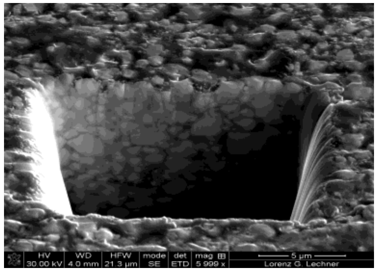
AMPEA SPB:
Materials for Extreme Operating Conditions

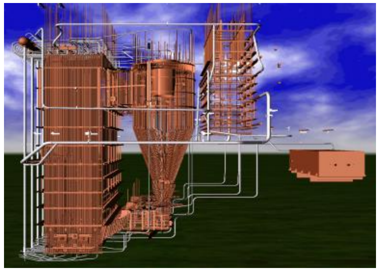
- **Basic material science:** Material composition, structure , stability, applied process technologies, testing methodologies
- **Characterization and testing of materials and devices in operating conditions**
- **Development of multiscale simulation and modelling approaches for sound life time predictions.**

Applications envisaged:

- Concentrated solar power,
- Geothermal,
- Bioenergy,
- Fuel cells,
- Highly efficient conventional energy conversion processes (e.g. gas turbines)
- …







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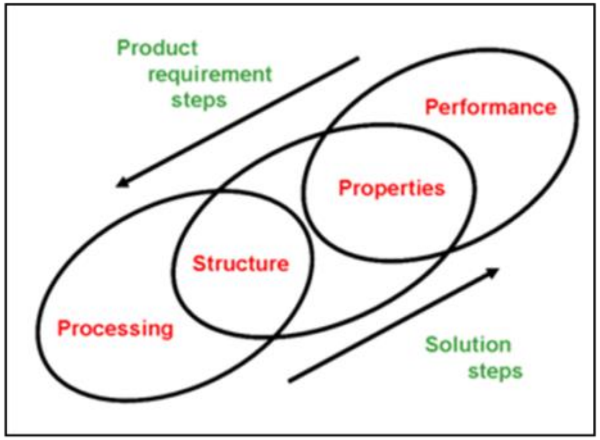
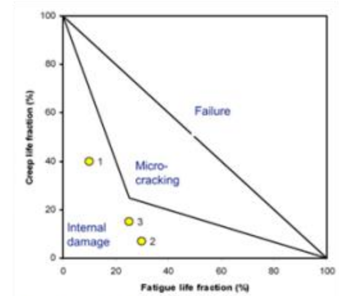
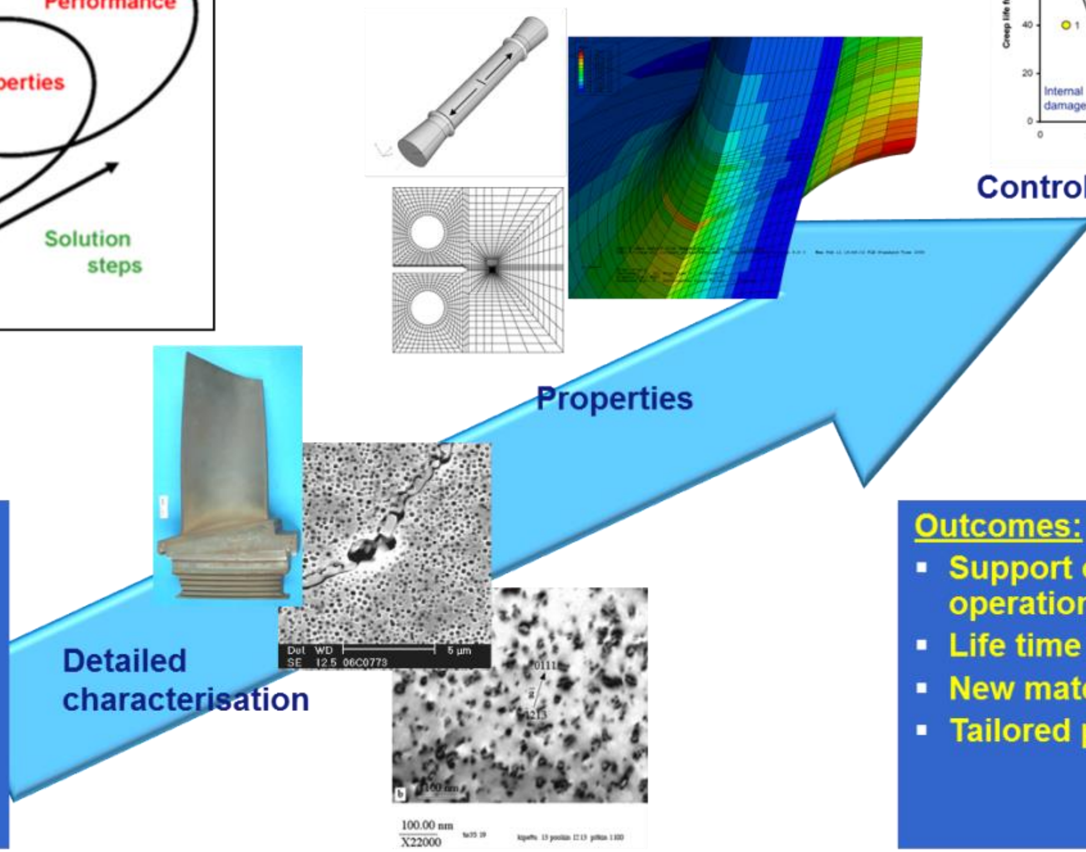
Links performance criteria to material structure and processing





Controlled performance



- **Deep understanding**
  - Materials
  - Processes
  - Characterisation
  - Performance
- **Multiscale modelling**

Outcomes:

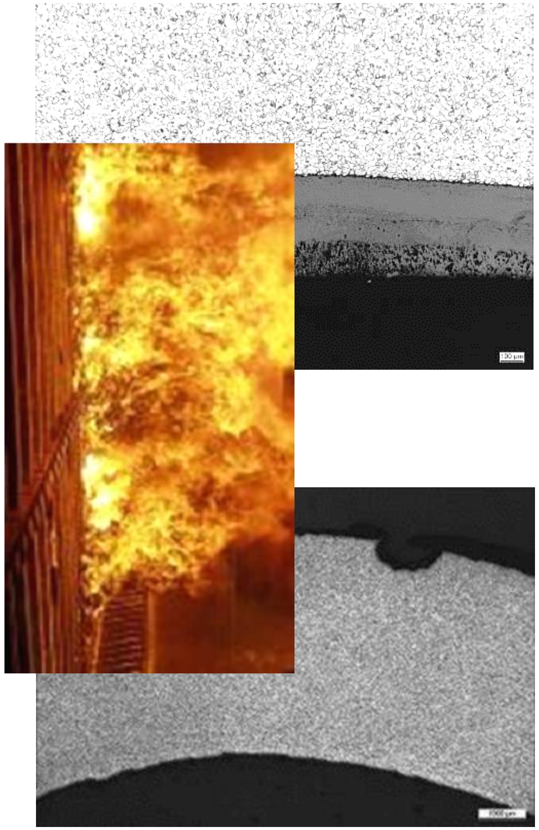
- **Support of design and operation**
- **Life time optimisation**
- **New material solutions**
- **Tailored performance**

Source: VTT

Thermal power plants

System requirements:

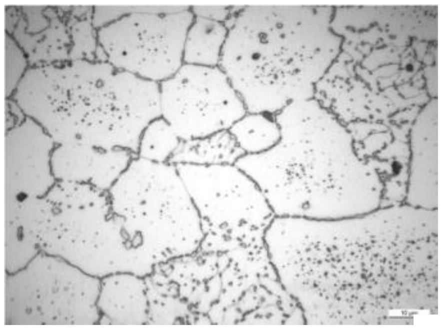
- Higher efficiency
- Longer life time
- Materials for processes involving high flexibility
- Materials for co-combustion
- Guidance for maintenance, repairs
- Tools for life management, monitoring methods
- Reduction of emissions
- Cost reduction



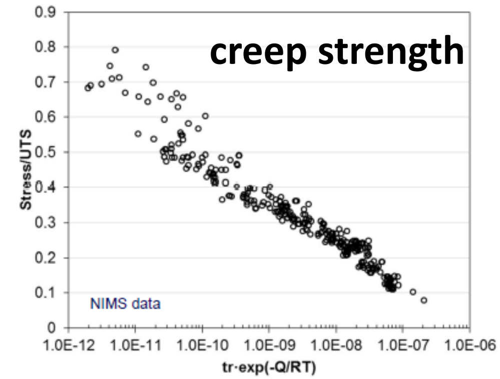
Material requirements:

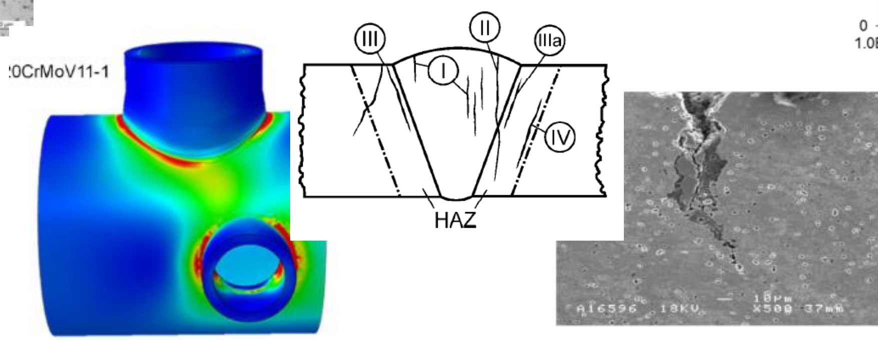
- Yield/tensile strength, ductility/toughness
- Creep (fatigue) strength with sufficient ductility
- Resistance to the target environment (e.g. oxidation, slagging, fouling, corrosion)
- Targeted range of physical properties
- Fabricability (e.g. weldability), cost as components

Thermal power plants: Metals, welds and coatings



Microstructural changes/degradation
- gradual weakening by e.g. precipitation of solid solution strengtheners and growth of particles & subgrains,



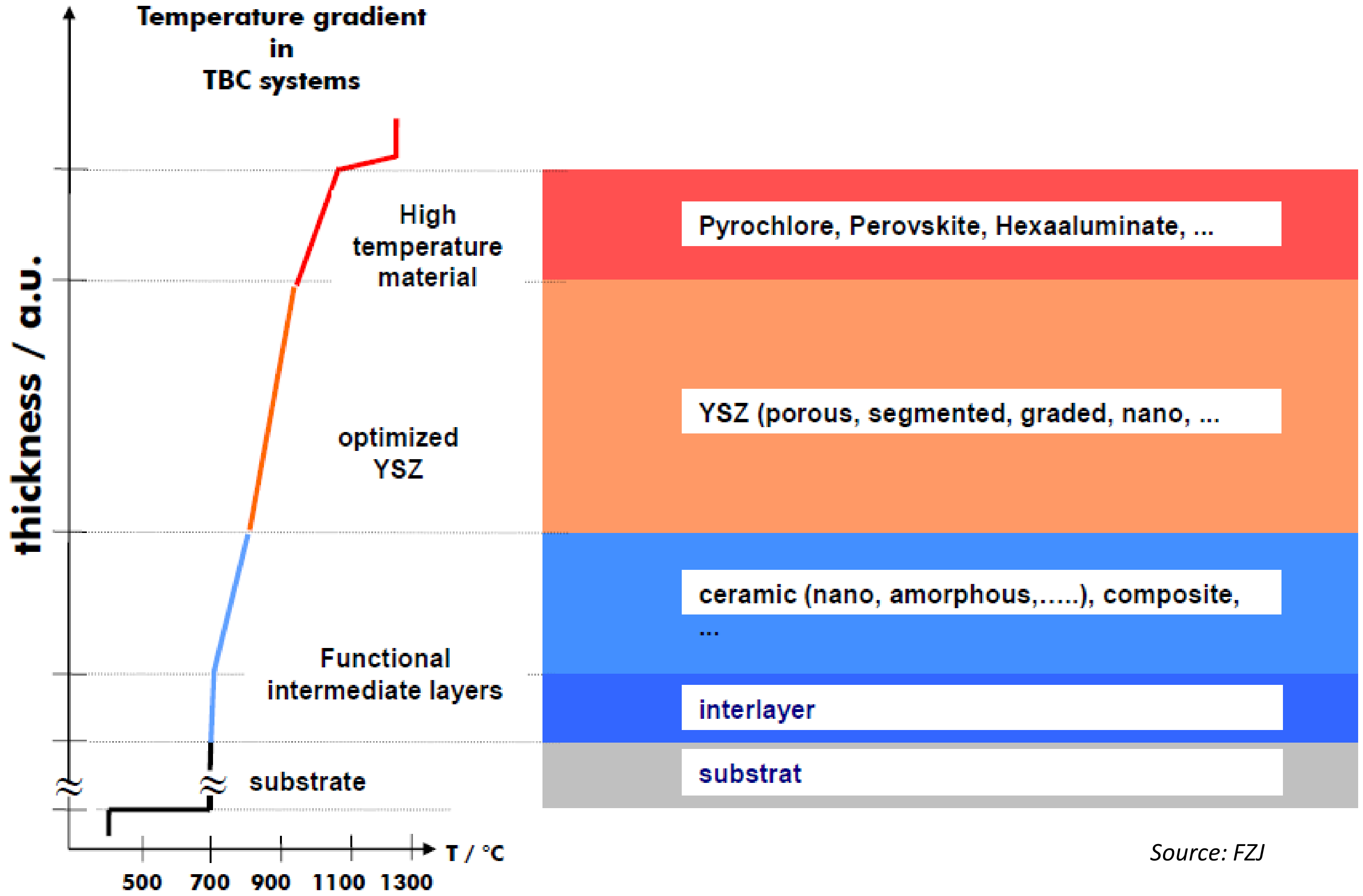


Spray coatings

Overlay welds

Source: VTT

Thermal power plants: Multi-layered TBC-systems

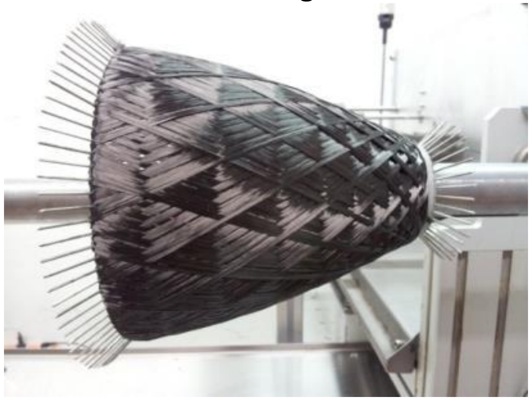


Source: FZJ

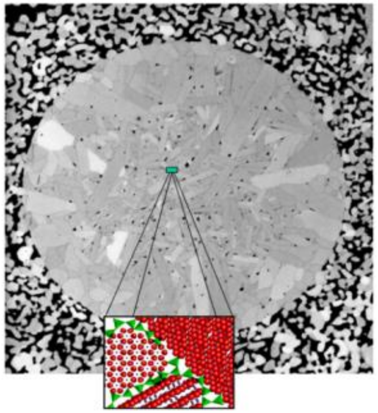
Thermal power plants: Ceramic Matrix Composites (Oxides, Non-oxides)

Advanced processing

Fiber winding

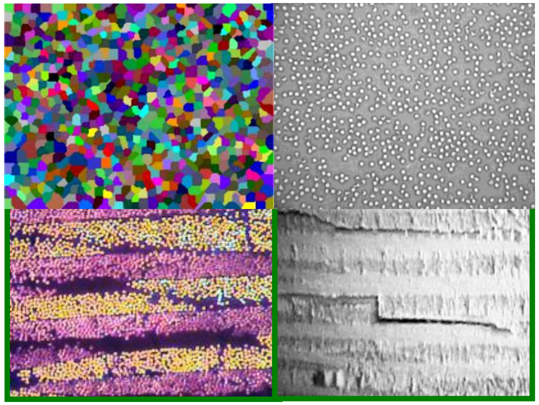


Source: DLR

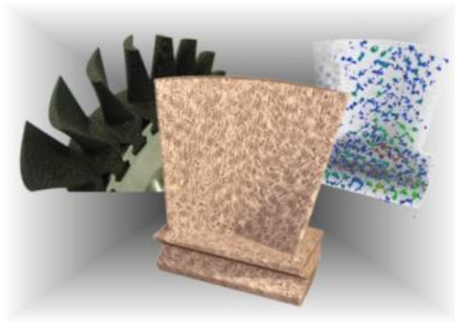


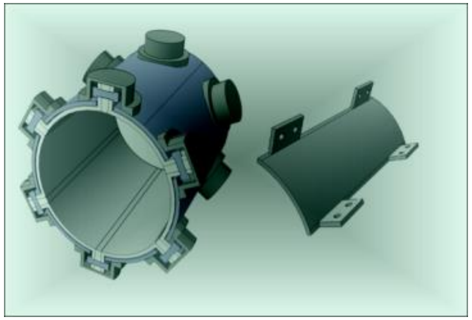
Microstructure -Properties Relations

Mesostructure/Property correlations



Damage tolerant high performance material for complex structures in severe environments

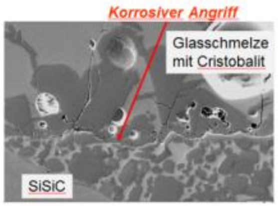


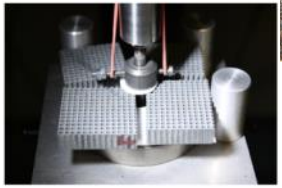


Materials for concentrated solar technology:

- ***Degradation of reflector systems in harsh desert environments***

- ***Development of selective absorbers***
- ***Interaction between absorber ceramics and mineral dust/melt***

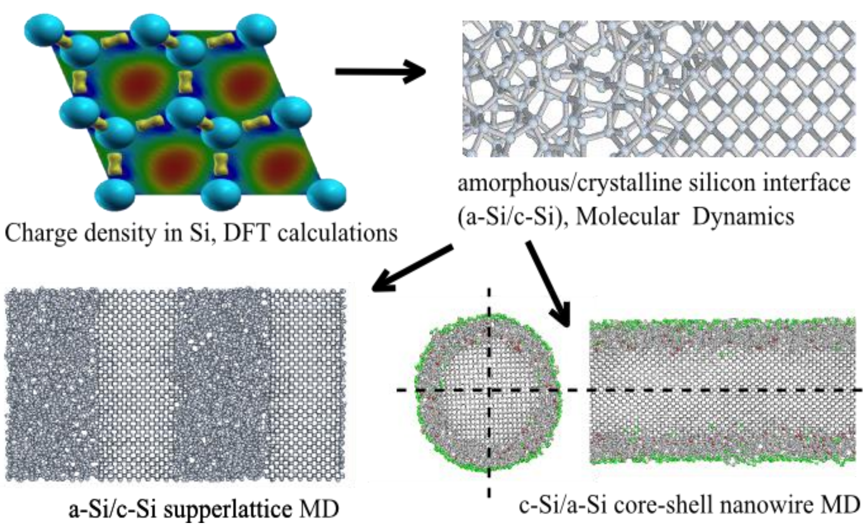




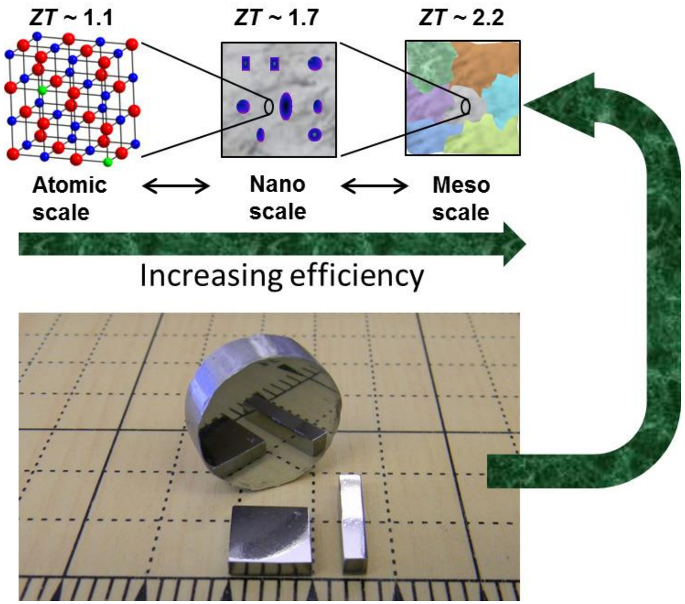
Source: DLR

Scientific collaboration in the frame of AMPEA – Models and tools for material design

Small scale modelling is fundamental to study and predict physical properties of materials. The latter one can be obtained with quantum mechanics using *ab-initio* methods



Application of DFT and MD to silicon based materials

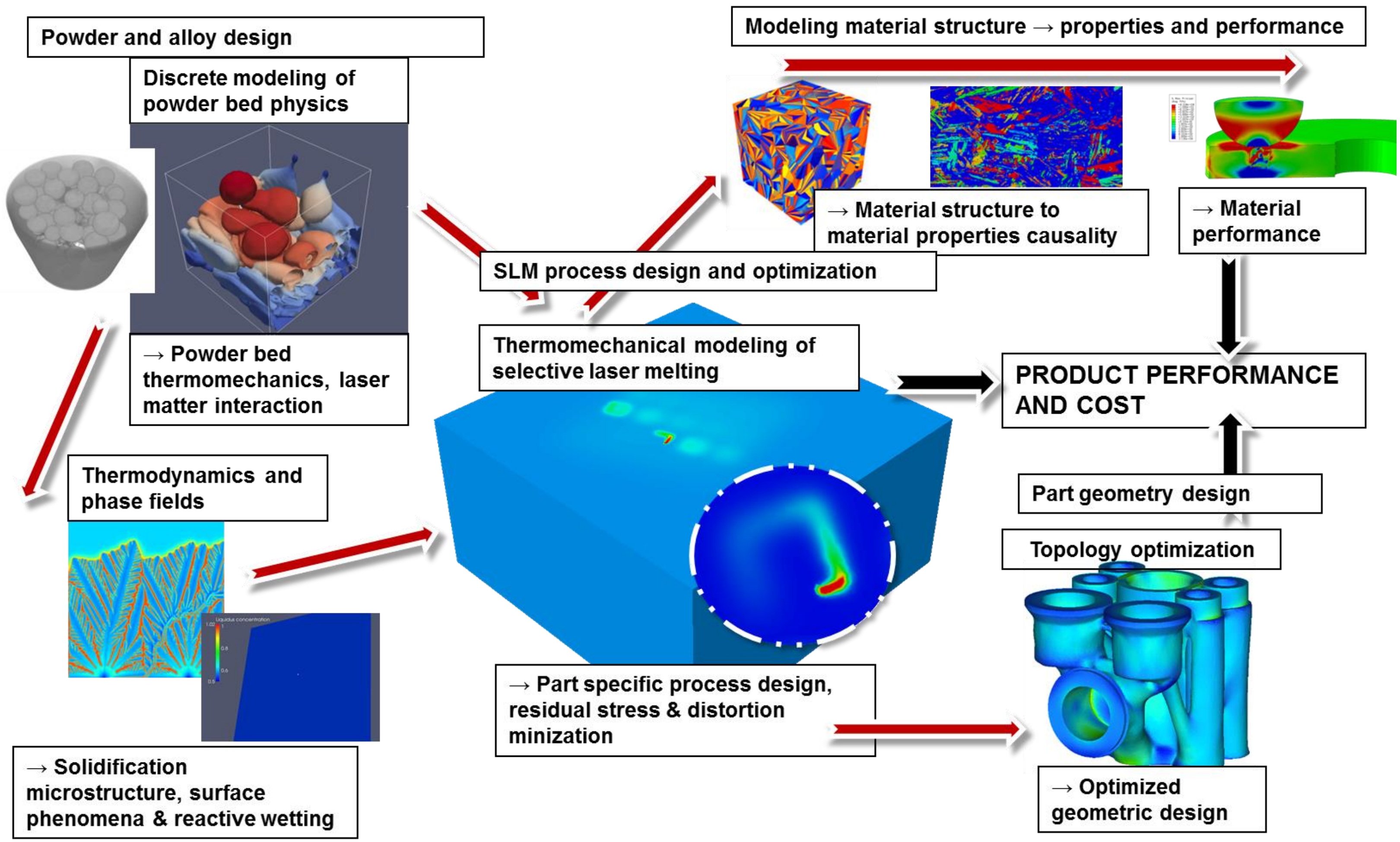


Application of DFT, MD and Monter Carlo techniques to improve thermoelectric materials

Need of access to large scale computation grids

Source: University of Lorraine

Multiscale modelling for metal additive manufacturing



Source: VTT

Thank you for your attention !