POLITECNICO
MILANO 1863

ARIES Project
Work Package 17 - 1st Workshop

ARIES

Torino, 27-28/11/17
Marco G. Beghi – Edoardo Besozzi

Possible contributions to WP 17 – Tasks 17.2 and 17.3

Task 17.2: Materials development and characterization

- Research, investigation, development and characterization of novel CMC and MMC based on graphitic, carbide or diamond reinforcements and dopants (in collaboration with Task 14.4).
  - measurement of the elastic properties by Brillouin spectroscopy
  - analysis of the structure of carbonaceous materials by Raman spectroscopy
- Study and development of electrically conductive coatings, resisting the impact of high intensity particle beams.
  - development of metallic (molybdenum ?) coatings, deposited by
    - laser ablation (Pulsed Laser Deposition, PLD) or by
    - HiPIMS (High Power Impulse Magnetron Sputtering)
- Characterization of thermophysical and outgassing properties, microstructural analyses, study of phases and of their change under various environments …
  - measurement of the thermal expansion coefficient of coatings

Possible contributions to WP 17 – Tasks 17.2 and 17.3

Task 17.3: Dynamic testing and online monitoring

Testing of material samples in a broad range of environments:

- Mechanical testing in quasi-static and dynamic conditions, at various temperatures
- Tests under very high power laser beams

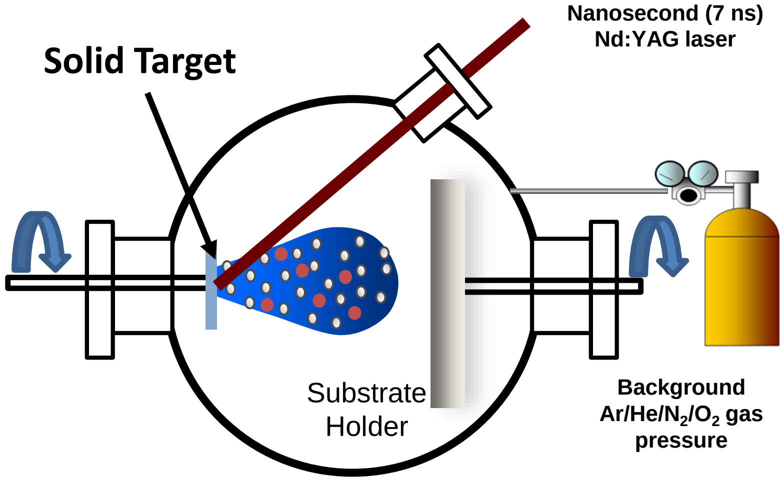
  below ablation threshold:

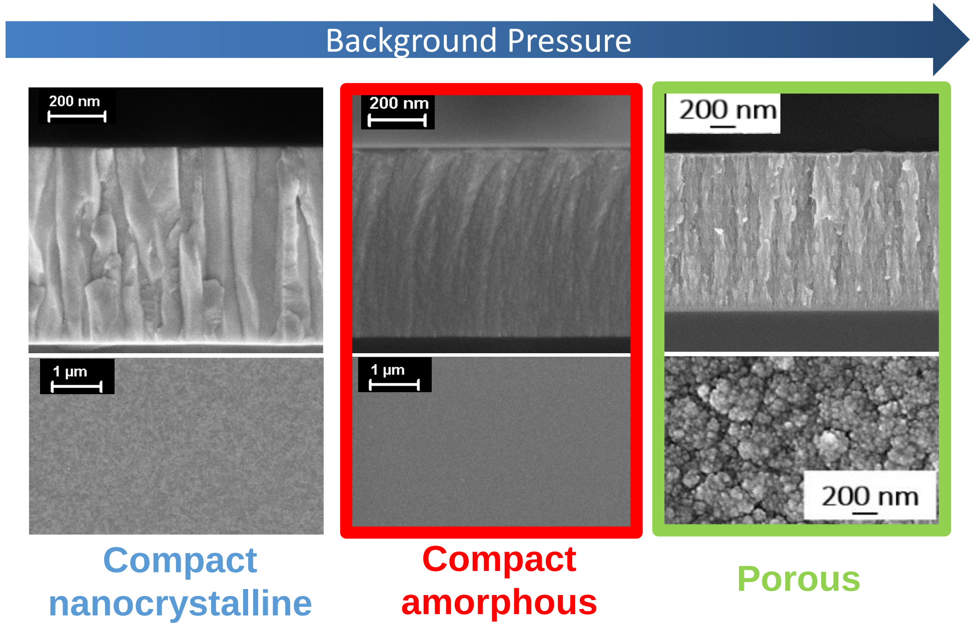
  - modeling of the temperature and strain fields (elastic waves) induced by laser pulses, also in multilayers
  - tests of irradiation by nanosecond laser pulses

- Irradiation tests with online monitoring of properties evolution
  - contribution to the design of irradiation tests and to the estimation of primary damage
- Hydrodynamic simulations of experiments – Equations of State, Spall Strengths for new materials

Coating deposition

By Pulsed Laser Deposition:





Long experience with W deposition (refractory bcc metal, akin to Mo)

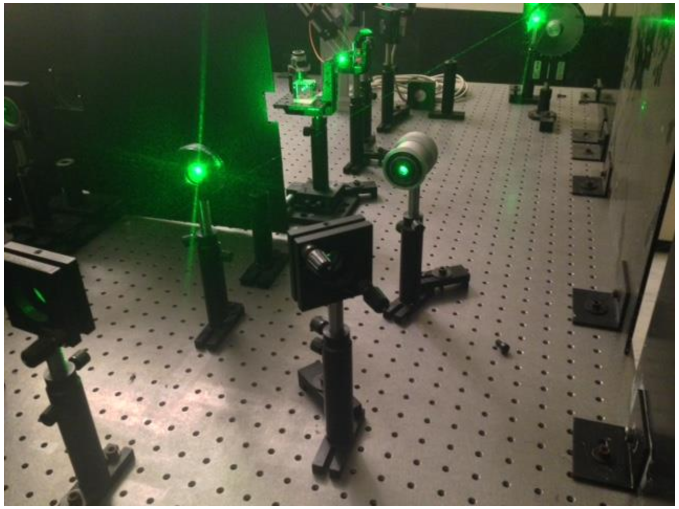
- PLD not best choice for compact metallic films
- but can mimick 'damaged' (non-compact, gas containing) coatings

By HiPIMS:

- deposition apparatus received on Friday 24th
- CERN has expertise on HiPIMS (coatings for RF cavities)

Coating characterization

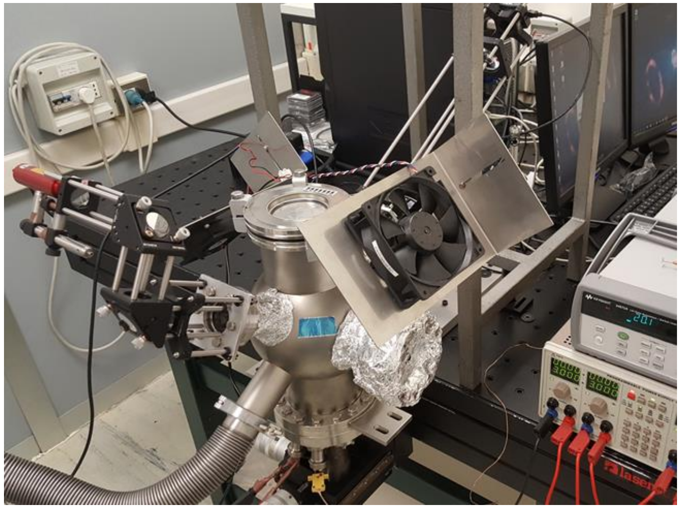
Brillouin spectroscopy



Elastic moduli

E. Besozzi, D. Dellasega, A. Pezzoli, C. Conti, M. Passoni, M.G. Beghi,
Amorphous, ultra-nano- and nano-crystalline tungsten-based coatings grown by Pulsed Laser Deposition: mechanical characterization by Surface Brillouin Spectroscopy
Materials and Design **106**, 14-21 (2016)

Substrate curvature technique

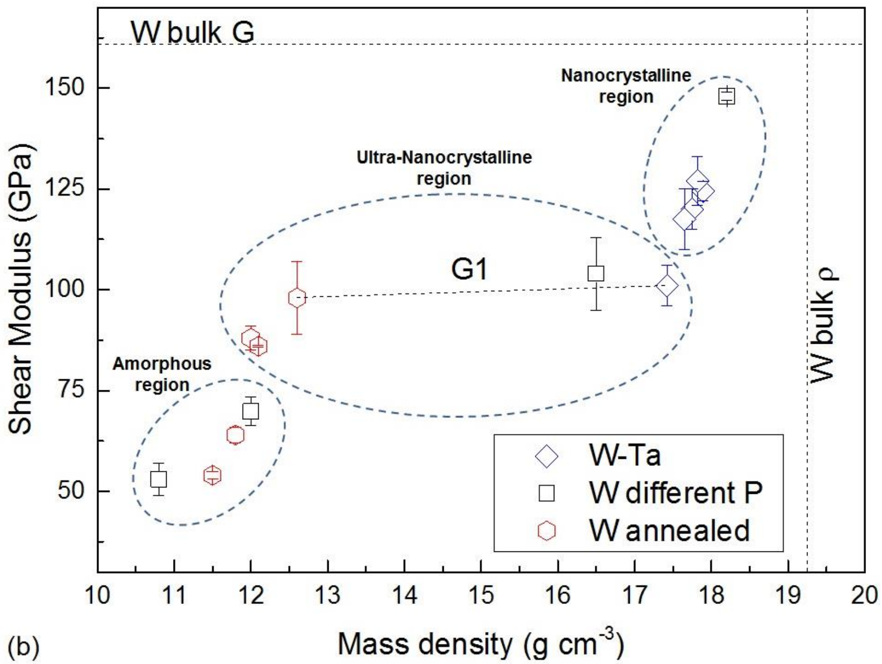


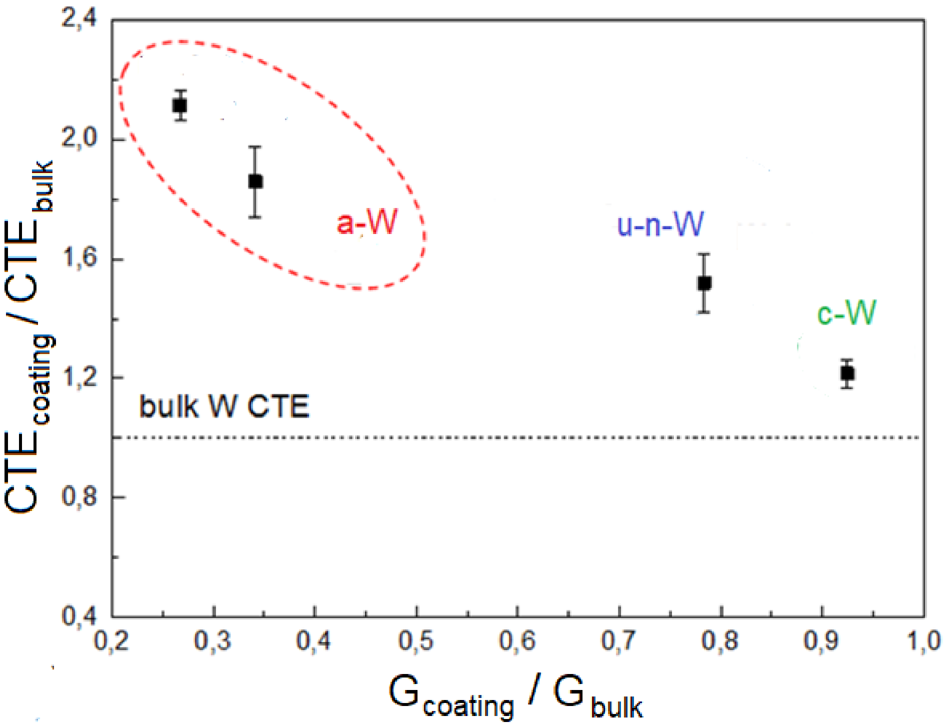
Coefficient of thermal expansion
Residual stresses

E. Besozzi, D. Dellasega, A. Pezzoli, A. Mantegazza, M. Passoni, M.G. Beghi,
Coefficient of thermal expansion of nanostructured tungsten based coatings assessed by substrate curvature method
Materials and Design, **137**, 192-203 (2018)

Recent research by Marco G. Beghi

W and W-Ta films (thickness: 200 nm ÷ 2 μm), deposited by laser ablation, different microstructures (amorphous, ultra-nano crystalline, and nano-crystalline)



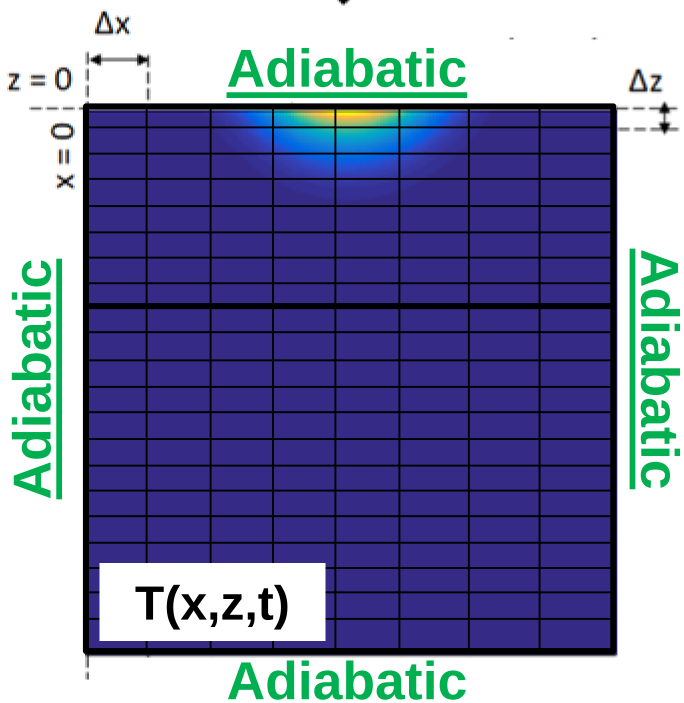


Irradiation by laser pulses: modeling

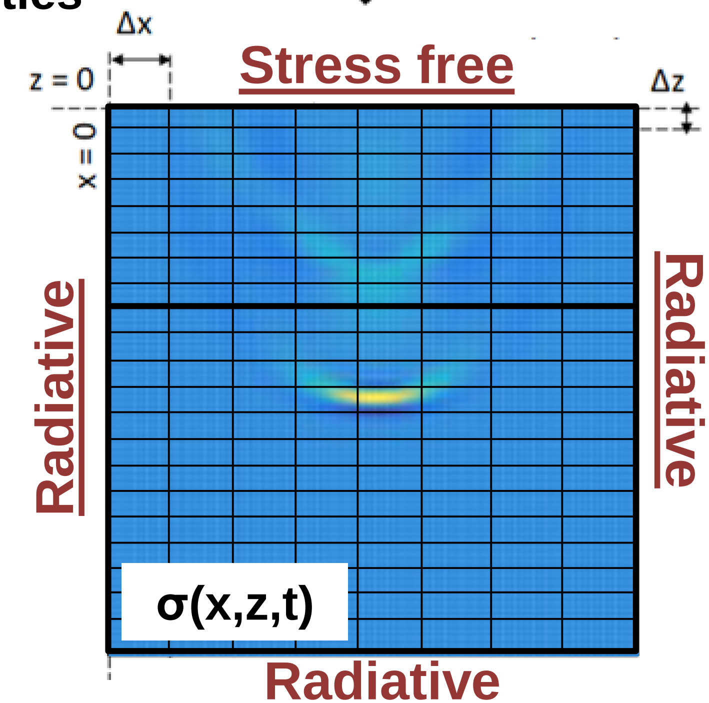
HEAT FLUX FACTOR: $HFF = P_0\,(1-R)\,\sqrt{(\Delta t)}$ $[MW\,m^{-2}\,s^{0.5} = MJ\,m^{-2}\,s^{-0.5}]$

- 2D Cartesian, finite differences discretization
- homogeneous, isotropic, linear elastic layers
- Perfect adhesion among layers
- Below ablation threshold:
  - temperature dependent material properties
  - no material modifications

thermal

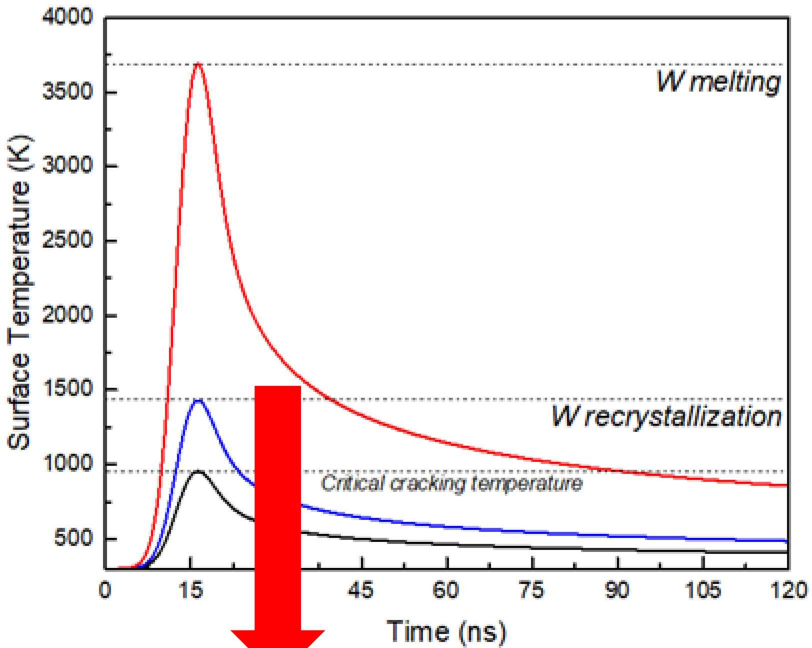


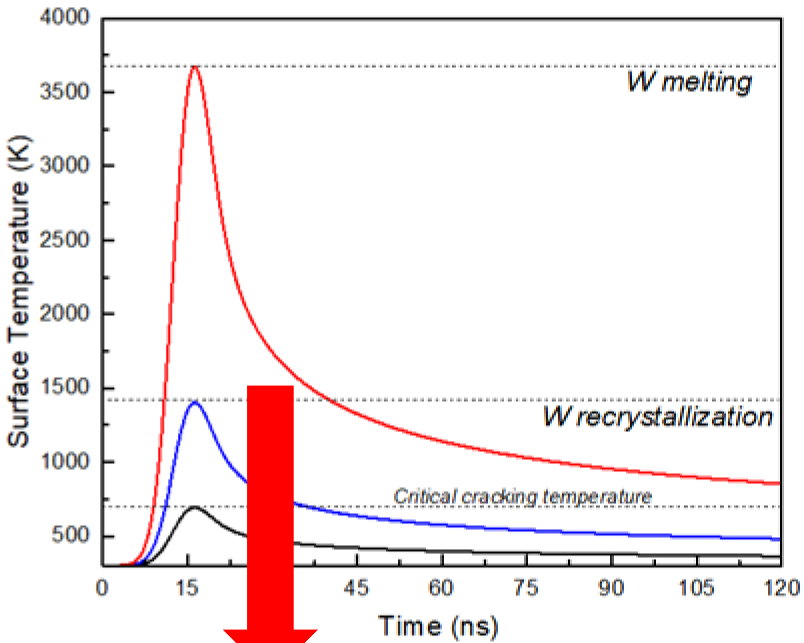
mechanical



Irradiation by laser pulses, below ablation threshold
Nd:YAG, 7 ns, ~ 0.1 J

c-W **a-W**





HFF = 54.8 MW m^{-2} $s^{0.5}$ **HFF = 27 MW m^{-2} $s^{0.5}$**

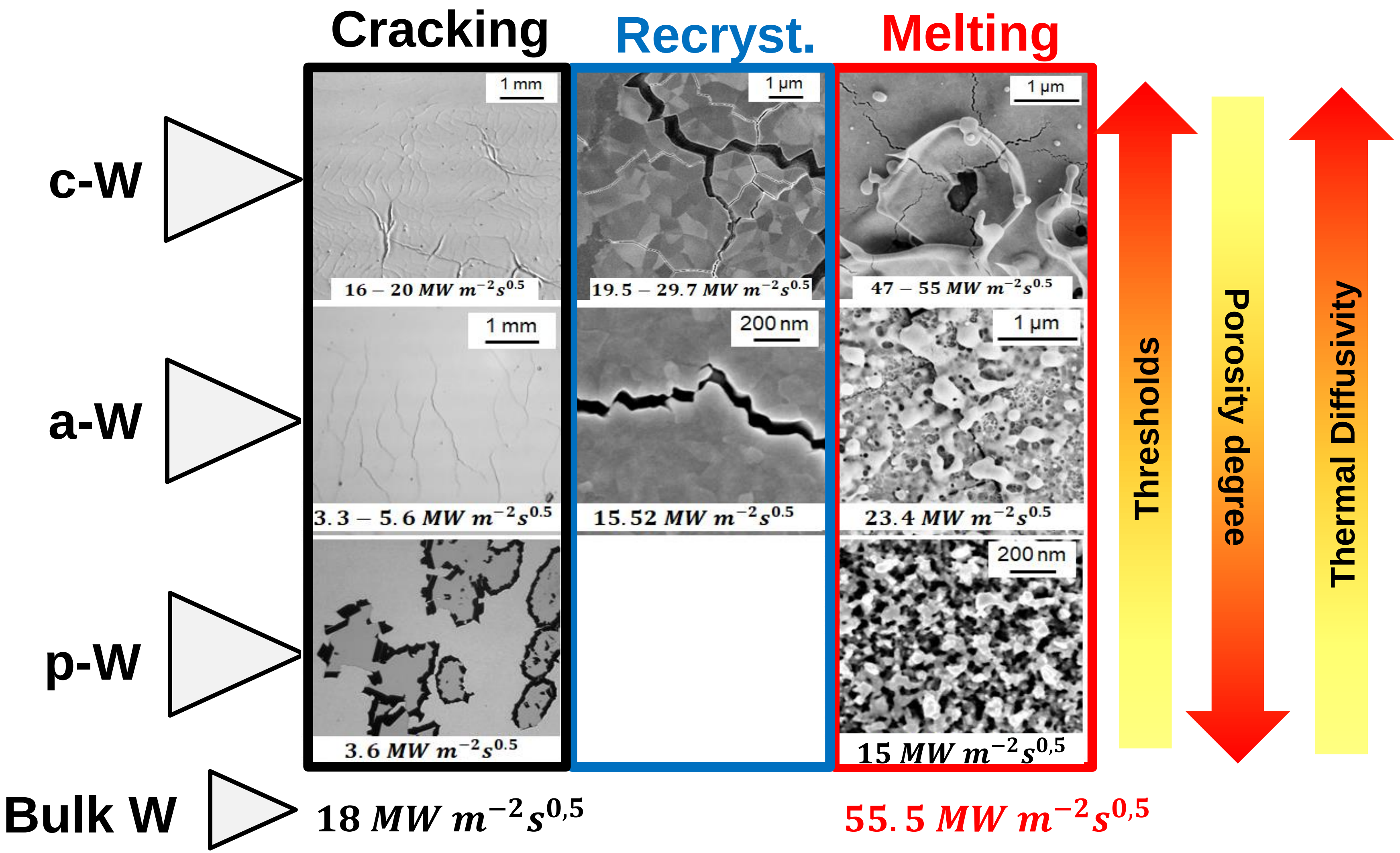
Experiments:

HFF = 47 - 55 MW m^{-2} $s^{0.5}$

Experiments:

HFF = 23.4 MW m^{-2} $s^{0.5}$

Irradiation by laser pulses



E. Besozzi, A. Maffini, D. Dellasega, V. Russo, A. Pazzaglia, A. Facibeni, M.G. Beghi and M. Passoni, under review (2017)

Possible contributions to WP 17