INTERACTIVE SESSION IV : COLLECTIVE EXERCISE ON AGGREGATE CALCULATIONS ON INTERNALS

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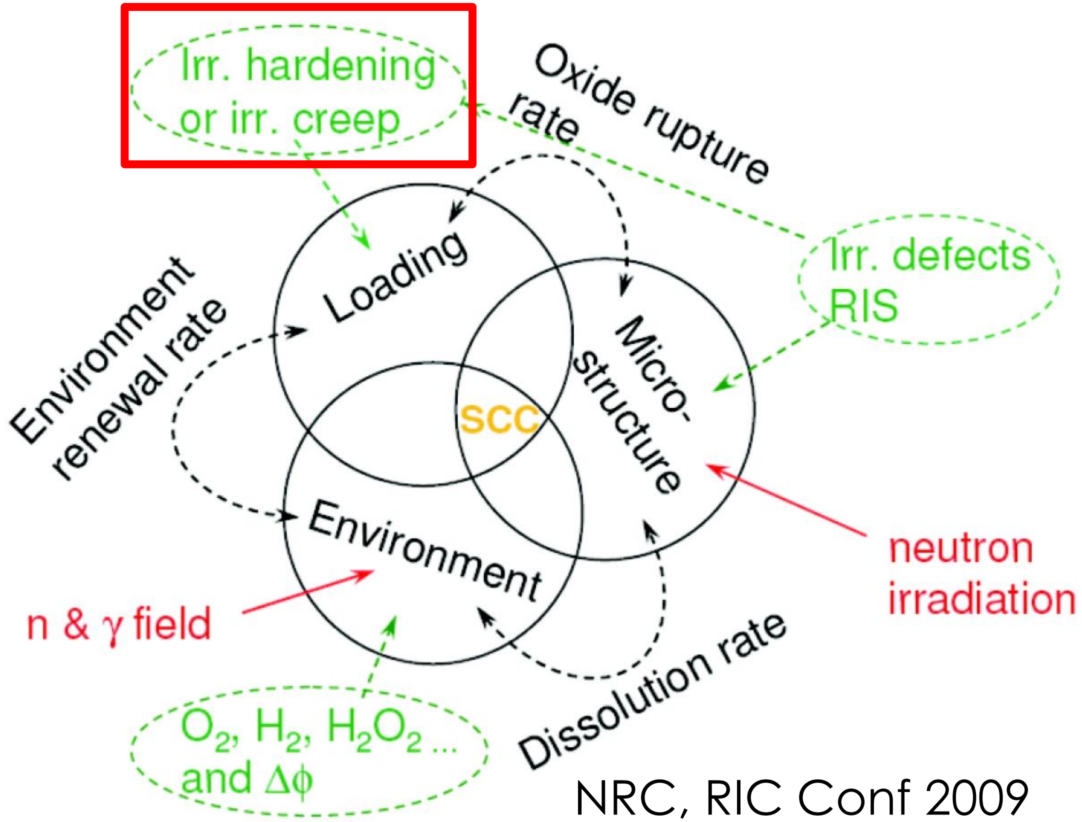
This project received funding under the Euratom research and training programme 2014-2018 under grant agreement N° 661913

Objective of the present study

Evaluation of the long term evolution of former-baffle bolts
→ effect of the evolution of the **mechanical properties** on the stress distribution at grain boundaries

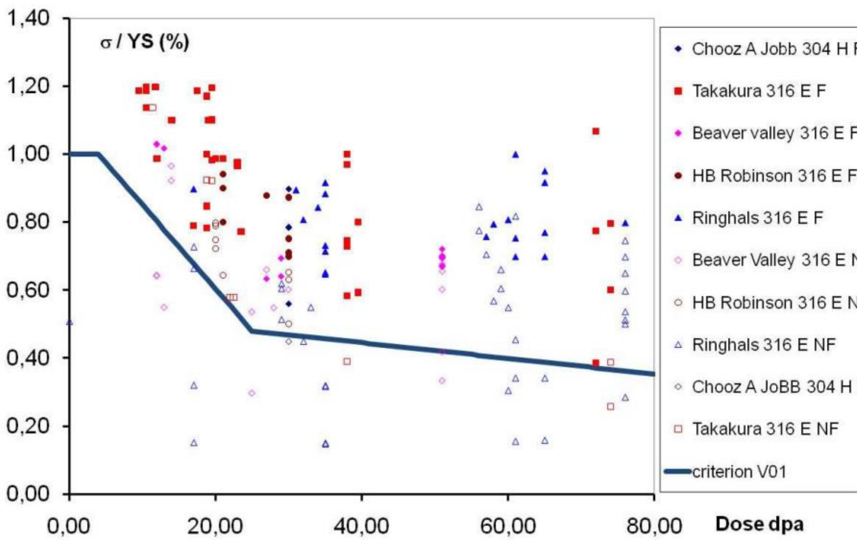
In-service cracking

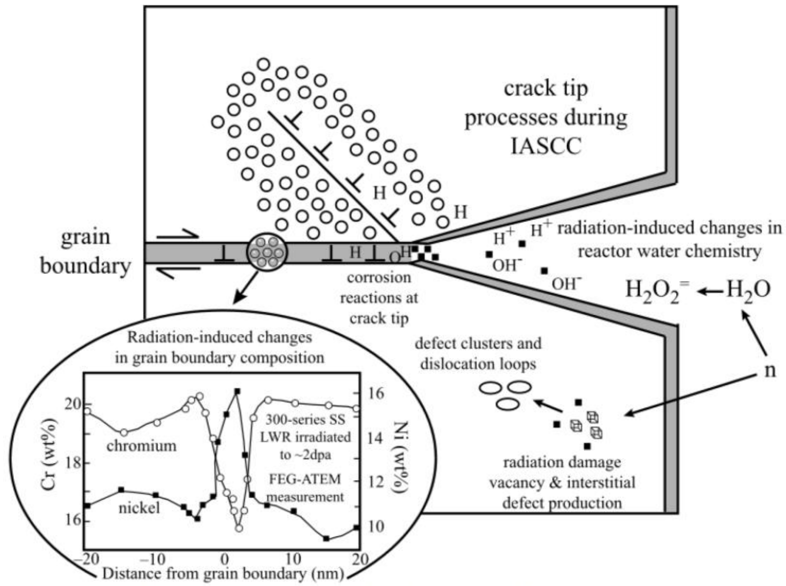


NRC, RIC Conf 2009

Criterion of IASCC

From the macroscopic stress to local approach to cracking





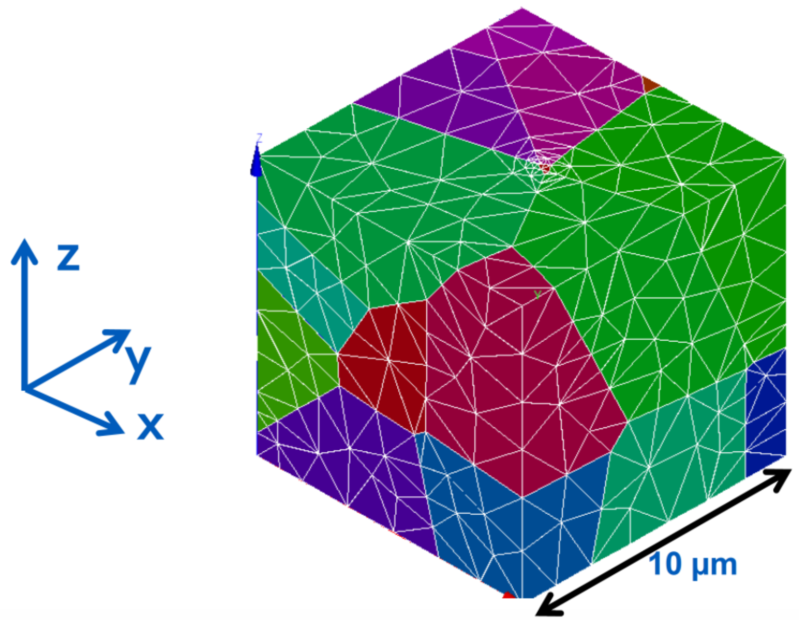
Gary S. Was Fundamentals of Radiation Material Science (2007)

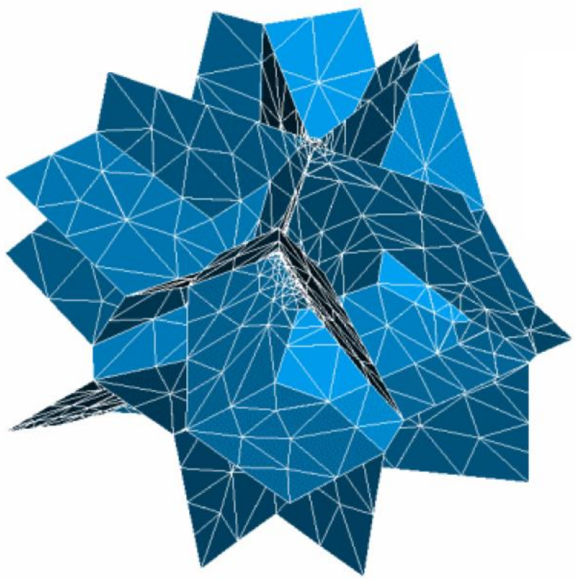
Difficult to find a single criterion to predict IASCC: cracking is a stochastic local phenomenon depending on many parameters.

Local criterion for cracking: definition of a critical stress σ_C

Simple model of aggregate

21 grains, 835 nodes, 3885 TET4





Grain boundary networks

The platform contains the mesh of the aggregate and input files for Code_Aster such as to perform Finite Element Mechanical calculations
+ post-processing tools to obtain stress distribution at grain boundaries

Crystal elasticity/plasticity law

Meric-Cailletaud law

$$\dot{\tilde{\varepsilon}} = \dot{\tilde{\varepsilon}}^e + \dot{\tilde{\varepsilon}}^p \qquad \dot{\tilde{\varepsilon}}^p = \sum_s \dot{\gamma}^s \overline{m}^s \otimes \overline{n}^s \qquad \dot{\gamma}^s = \left\langle \frac{\left|\tau^s - x^s\right| - \tau_c^s}{K_s} \right\rangle^{n_s} \frac{(\tau^s - x^s)}{\left|\tau^s - x^s\right|} \qquad \tau^s = \tilde{\sigma} : \tilde{m}^s$$

Kinematic hardening

$$x^s = c\,\alpha^s$$

$$\dot{\alpha}^s = \dot{\gamma}^s - d\alpha^s \left|\dot{\gamma}^s\right|$$

Isotropic hardening

$$\tau_c^s = \tau_0 + Q \sum_r h_{rs} \left(1 - \exp(-b\gamma_{cum}^r)\right)$$

$$\gamma_{cum}^r = \int_t \left|\dot{\gamma}^r\right| dt$$

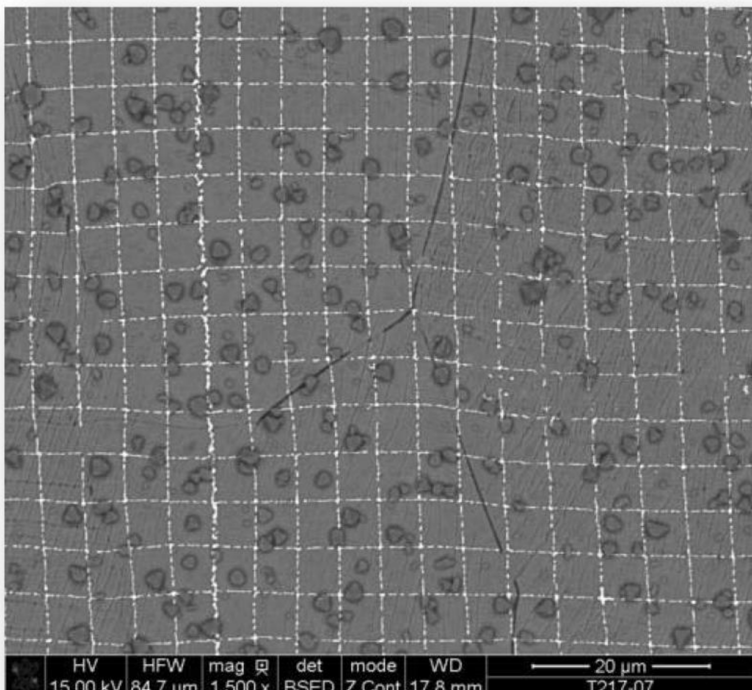
Temperature (°C)	E (MPa)	n	τ_0 (MPa)	Q	b	K (MPa.s$^{1/n}$)	n	c	d
20	200000	0,3	65	45	3	65	7	600	20
360	185000	0,3	50	45	3	10	4	600	20

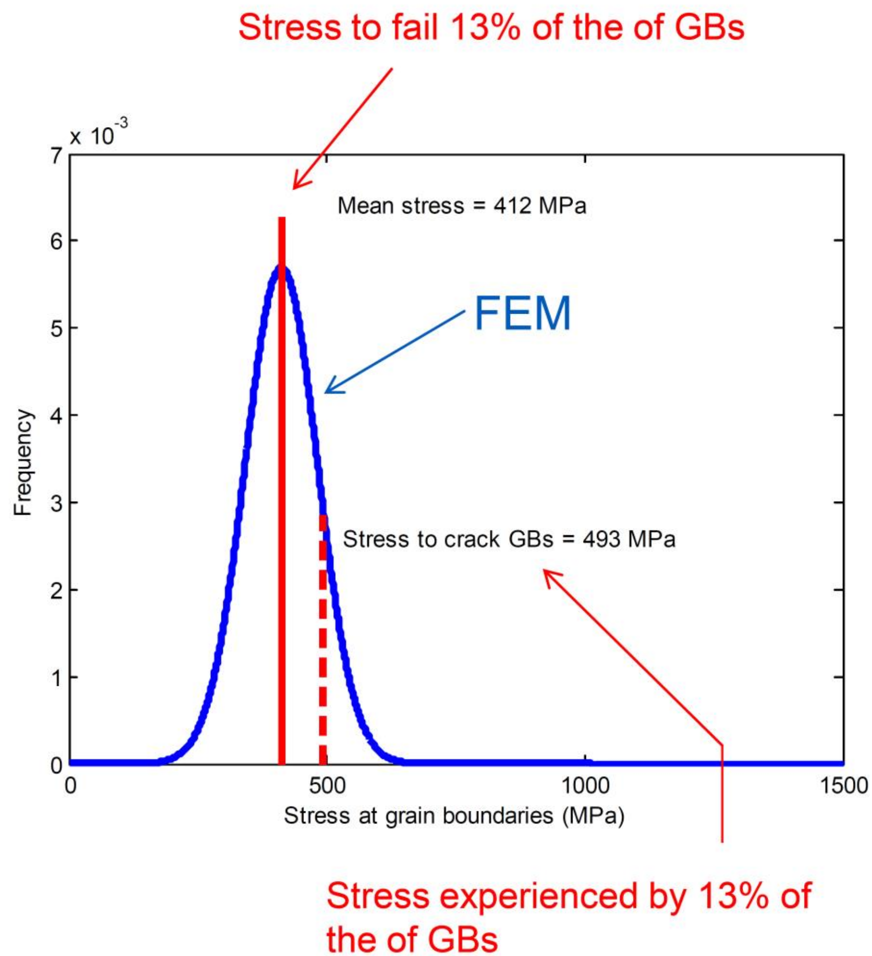
Thierry Couvant, EDF R&D

Examples of IASCC applications

Tensile test at 360°C of a pre-oxidized specimen (316L)

13% of the total length of GBs failed under 412 MPa





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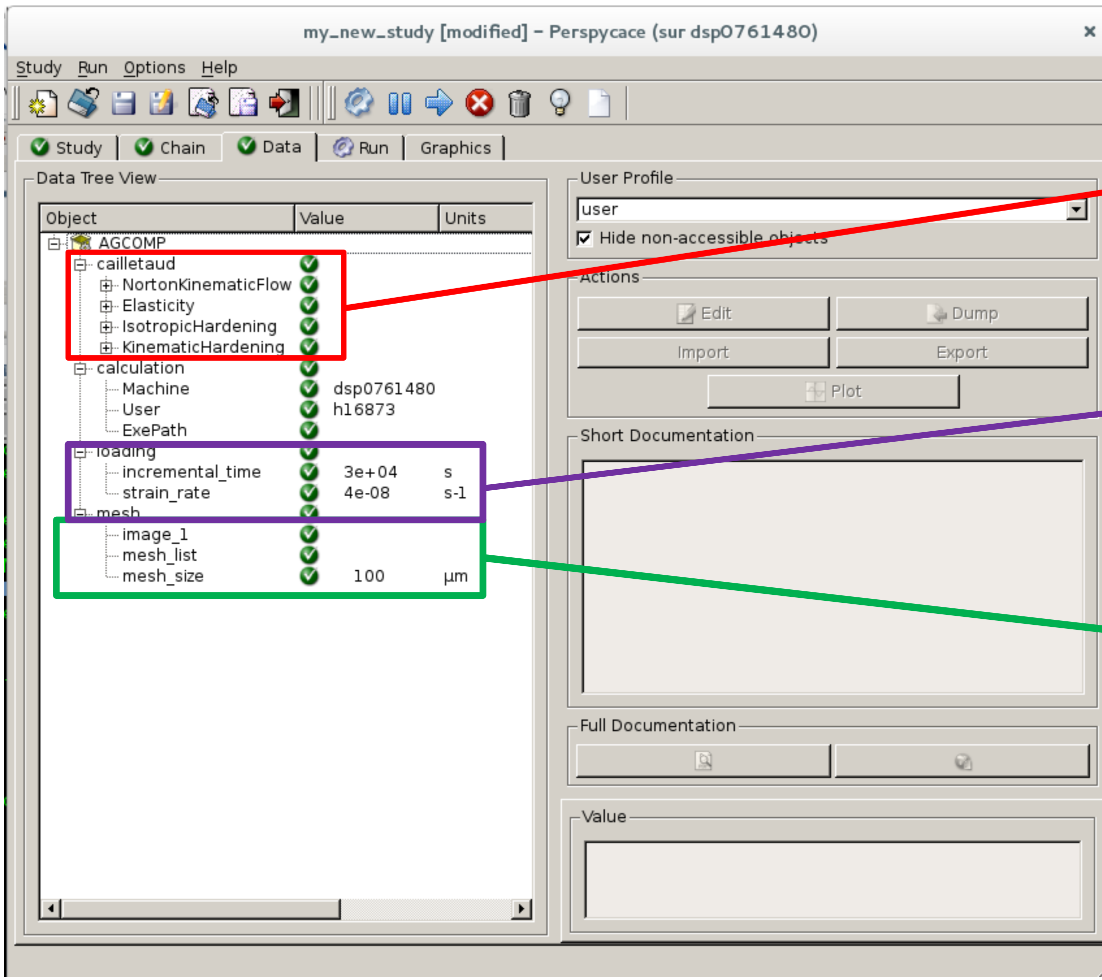
AGCOMP Module

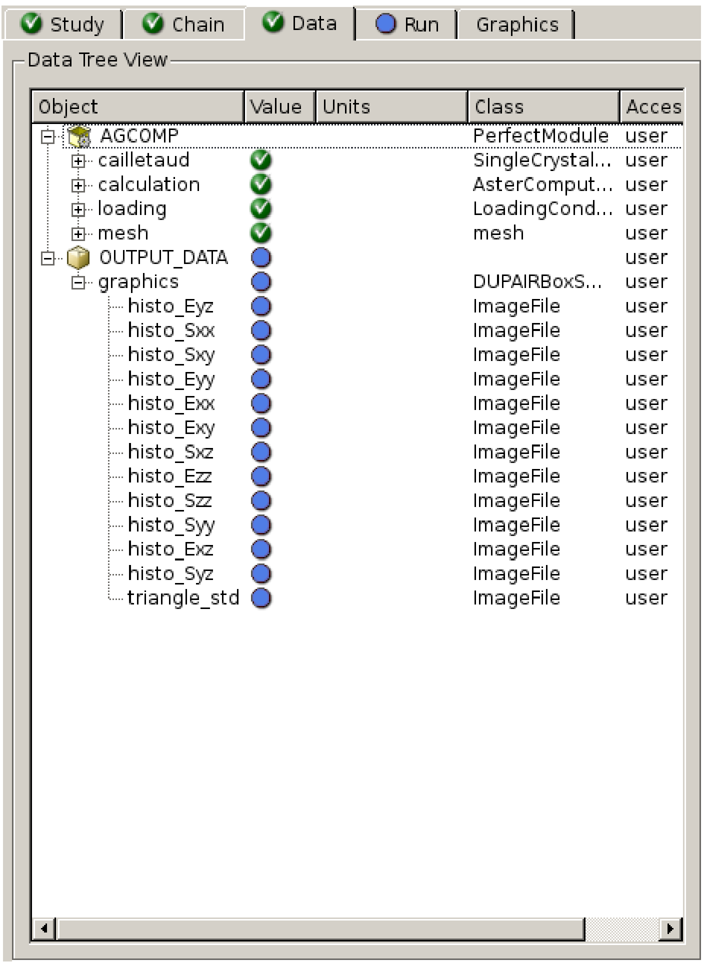


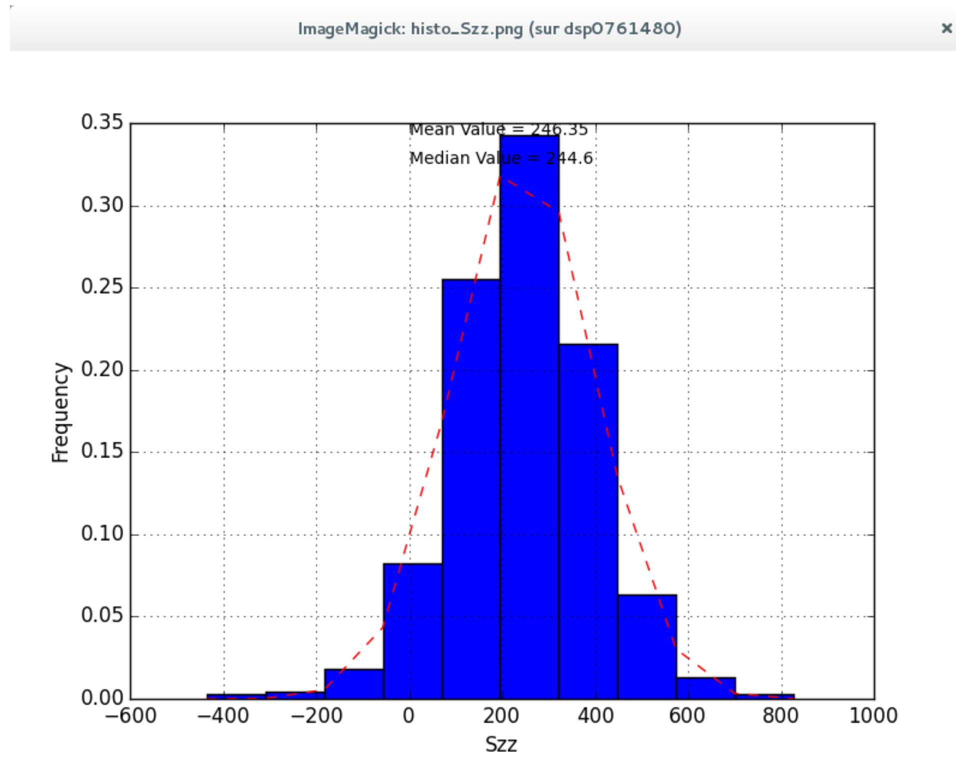
Méric Cailletaud parametrization

Loading parameters

Mesh is automatically provided

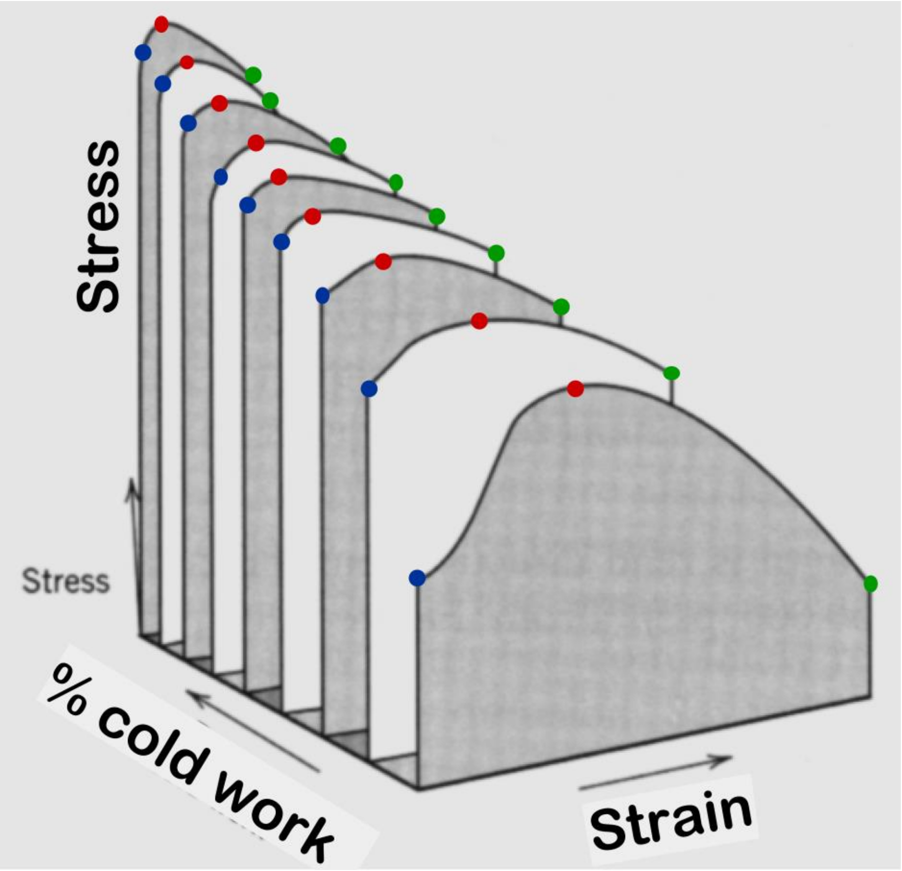
AGCOMP Module





Stress distribution over all the grain boundaries of the model

Work hardening



Yield strength/Tensile strength increases while ductility decreases considerably