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Dynamic Indentation Induced Damage in Si_3N_4

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Cluster 02 : Multi-scale fundamentals of materials, Project : M23.2.09347
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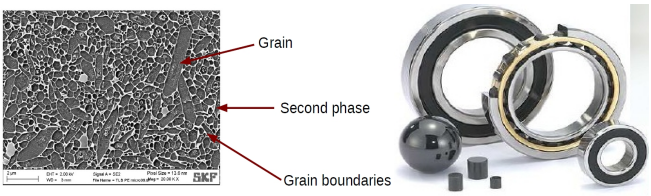
Aim of the project



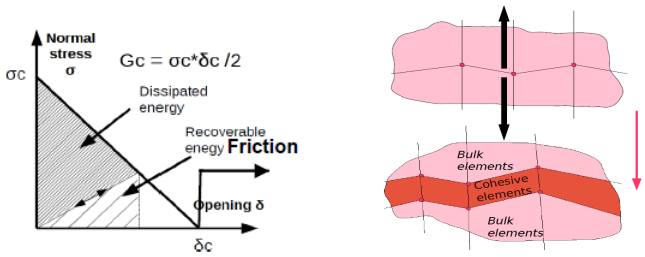
Micro-structure of Si_3N_4, hybrid bearing

Our goal in this project is to model damage mechanisms at the micro-structural level within Si_3N_4 ceramics in view of improving macroscopic toughness. This ceramic is used by our industrial partner (SKF) as rolling elements in hybrid bearings. The challenges originate from:

- Competition between intra-granular and trans-granular cracking.
- Frictional contact at damaged interfaces.
- Uncertainty and heterogeneity in microscopic properties (grain boundaries, pores, second phases)

Approach

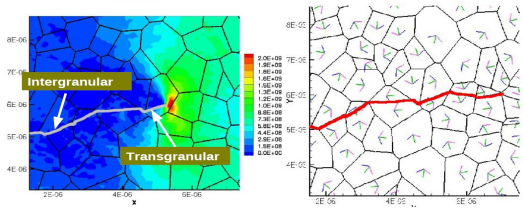
Our simulations are conducted with an explicit 2D FE code under plane strain conditions. The micro-structures are developed using Voronoi tessellation. We model the dynamic crack propagation explicitly using the cohesive element framework. We resort to a linear reversible cohesive law [1] for inter-granular and trans-granular cracks, whereas the bulk behaviour is considered as homogeneous, isotropic and elastic. Once the interfaces are damaged a frictional multi-body contact algorithm is called for.



Associated crack energy and cohesive element

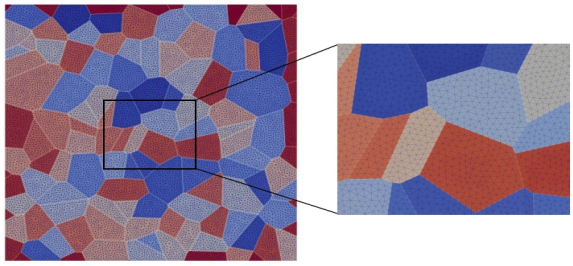
Results

Simulations showing inter-granular and trans-granular



Typical inter-granular and trans-granular crack modeling

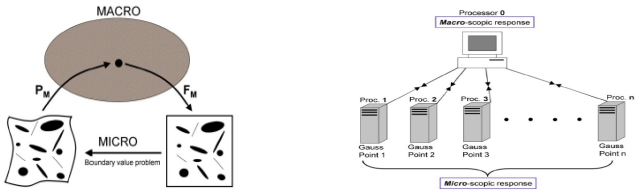
fracture have been run by R. Kraft [2]. We are now able to generate voronoi microstructures with elongated grains thanks to a new collaboration with Dr. P. Kok from Tata Steel.



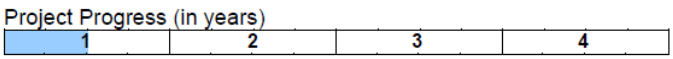
Typical Voronoi mesh

Future work & Valorisation

Our next objective is to consider porosity and amorphous phase in our model and conduct parametric studies on the influence of these two parameters. We are also going to calibrate the parameters of our model with the experimental data we will get from the literature and SKF. Our long term objective is to implement a multi-scale model for indentation damage.



Multi-scale approach



References

[1] G. T. Camacho, M. Ortiz., Int J. Solids Structures (1996) 33, 2899-2938.

[2] R.H. Kraft, J.F. Molinari, Acta Materialia (2008) 56, 4739–4749.

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