Dynamic multi-scale modelling for micro-manufacturing processes of polycrystalline materials

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Abstract (300 word limit)

Statement of the Problem: Polycrystalline materials are widely exist in nature and extensively used in industries. With the feature size reduced to micro-nanometer level, the anisotropic nature of polycrystalline materials and the size effect of micro-manufacturing processes become significant, thereby the continuum theory based simulations are no longer applicable to explain the mechanical response. Researchers have developed strain gradient theory to explain the size effect phenomena, unfortunately, the acquisition of strain gradient parameters from literature and experiments is difficult, and the anisotropic nature of polycrystalline materials is failed to be considered. In recent years, researchers began to explore grain scale modelling methods that discuss the influence of size and anisotropic behaviors of grains on material properties. However, the basic knowledge system has not been formed as an enough research has not been done, existing grain scale modelling methods fail to consider necessary grain scale information of the actual material comprehensively, and it is too expensive and inefficient to simulate the whole part in grain scale. The purpose of this study is to propose a dynamic multi-scale modelling method for micro-manufacturing processes of polycrystalline materials. Methodology: Firstly, a pseudorandom based grain scale geometry was generated by taking full advantage of true grain scale microstructure information. Secondly, Strain gradient parameters was obtained through CPFE based simulations. Thirdly, dynamic multi-scale model was established by modelling Key areas in grain scale and nonessential areas in continuum scale. Fourthly, stress state based scale transformation between grain scale area and continuum area will be continuously proceed during micro-manufacturing processes. Findings: the dynamic multi-scale model is superior to continuum model in terms of accuracy and superior to pure grain scale model in terms of efficiency. Conclusion: a dynamic multi-scale model was established for polycrystalline materials, which can simulate micro-manufacturing processes in high accuracy and high efficiency simultaneously.

Image

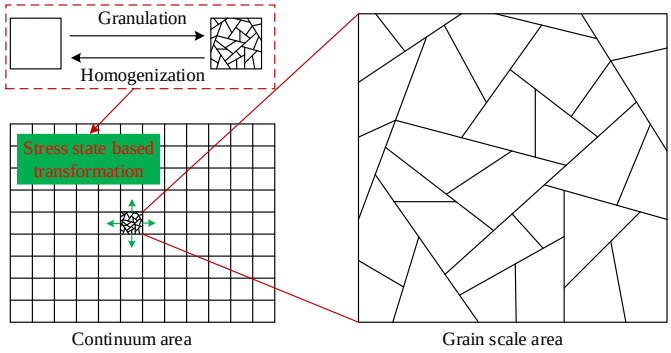


Figure 1: Dynamic multi-scale model

Recent Publications (minimum 5)

1. Ji HS, Song QH (2020) A pseudorandom based crystal plasticity finite element method for grain scale polycrystalline material modeling. Mechanics of materials 144:103347.
2. Gupta MK, Song QH (2020) Machining characteristics based life cycle assessment in eco-benign turning of pure titanium alloy. Journal of Cleaner production 251:119598.
3. Wang XJ, Song QH (2020) Precise chatter monitoring of thin-walled component milling process based on parametric time-frequency transform method. Journal of materials processing technology. Journal of materials processing technology 283:116712.
4. Gupta MK, Ji HS (2020) Impact of layer rotation on micro-structure, grain size, surface integrity and mechanical behaviour of SLM Al-Si-10Mg alloy. Journal of materials research and technology 9:9506-9622.
5. Du YC, Song QH (2019) Size-dependent responses of micro-end mill based on strain gradient elasticity theory. International journal of advanced manufacturing technology 100: 1839-1854.



Biography (150 word limit)

Hansong Ji has his expertise in multi-scale modelling and simulations for polycrystalline materials. He is 27 years old and is a PhD student in the school of mechanical engineering, Shandong University, major in process mechanical engineering. He has been awarded the Chinese Government Scholarship for a one-year visit in University of Strathclyde. He has published 4 SCI papers in his area, particularly, he has proposed a pseudorandom based CPFE method for grain scale polycrystalline material modelling, which is better than EBSD copying method and Voronoi method in terms of simulation efficiency, representativeness, strain rate stability, mesh density stability and truth proximity

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Notes/Comments: