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Micromachining with Nanostructured Cutting Tools

 Springer

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Preface

There is a substantial increase in the specific energy required with a decrease in the depth of cut during micromachining. It is believed this is due to the fact that all metals contain defects such as grain boundaries, missing and impurity atoms, substitutional atoms, defects, secondary phases, etc., and when the size of the material removed decreases the probability of encountering a stress—reducing defect decreases. Since the shear stress and strain in metal cutting is unusually high, discontinuous microcracks usually form on the primary shear plane. If the material is very brittle, or the compressive stress on the shear plane is relatively low, microcracks will grow into larger cracks giving rise to discontinuous chip formation. When discontinuous microcracks form on the shear plane they will weld and reform as strain proceeds, thus joining the transport of dislocations in accounting for the total slip of the shear plane. In the presence of a contaminant, such as carbon tetrachloride vapor at a low cutting speed, the re-welding of microcracks will decrease, resulting in a decrease in the cutting force required for chip formation. The initial part of this ‘Springer Brief’ briefly describes the process of micromachining and the underlying theories that describe chip formation and it shows how elementary cutting theory can be applied to machining at the microscale.

The second part shows how frictional interactions between uncoated and micro tools coated with nanostructured coatings can be characterized by using the elementary micromachining theories that were initially developed for machining at the macroscale. Shaw’s methods for calculating temperatures at the interaction zone and Merchant’s methods for calculating mechanical interactions are well described and justified for machining steel in both the dry and wet states. The further development and use of micro tools coated with thin-film nanostructured diamonds are shown in the third part of this ‘Springer Brief’. The

brief is written specifically for engineers and scientists working in this new field of micro and nanotechnology, and it explains how to characterize, apply, and adapt traditional approaches of understanding the mechanics of practical machining to the machining of microproducts using nanostructured tools.

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