

Preface

As well as its obvious uses in jewellery, diamond is a desirable material for a wide range of mechanical, chemical, optical, thermal and electrical applications. Some good examples are cutting tools, wear components, integrated circuit substrates, non-memory semiconductors and optical windows. As such, the production of synthesis diamond has doubled in the past decade, and is estimated to be more than 8 billion carats a year. With the development of new processing technologies, the cost for producing synthesis diamond and its composites has significantly reduced. Hence, diamond and its composites are more extensively being used in the industry. In most applications, however, the material surfaces must have an excellent finish, which leads to an increasing demand of efficient and cost-effective techniques for polishing diamond surfaces.

Because of the extreme hardness and chemical inertness of diamond, the polishing of diamond and its composites is very difficult. Over the years, various techniques by mechanical, chemical or thermal means or by their combinations have been developed. In production practice, nevertheless, it is always important to select an appropriate polishing technique based on a specific application requirement, depending on, for example, the component geometry, the equipment available, the efficiency and the economic constraints; otherwise, polishing-induced damage can occur, or production may become cost-ineffective.

This book details the state-of-the-art techniques which are available for polishing diamond and polycrystalline diamond composites. The book comprises 11 chapters. [Chapter 1](#) begins with an overview of the unique constellation of the superlative properties of diamond. This introduction is required for an effective design of a proper polishing technique.

[Chapter 2](#) explains the possible material removal mechanisms in the process of diamond polishing. Such basic understanding is important to the selection and development of specific polishing techniques. This chapter also provides a summary of the current understanding of the material removal paths with regard to each of the polishing techniques.

[Chapter 3](#) provides a comprehensive description of the traditional mechanical polishing technique and its applications, with an introduction to the polishing equipments that have been widely used in the industry. The application of the mechanical technique to the polishing of mono/poly-crystalline diamond and

chemical vapour deposition (CVD) diamond films is discussed here. The anisotropic material removal rate and its influence on polished surface quality are also outlined.

Chapter 4 discusses the chemo-mechanical polishing method. As the title of the chapter indicates, the focus of this chapter is to describe the way of introducing the chemical effect into the polishing of diamond to improve the material removal efficiency and to obtain ultra-smooth surfaces. From the methodology point of view, the discussion in this chapter can also be viewed as a highlight of the importance of non-mechanical factors to the development of fast and quality surfacing techniques for hard-to-machine materials.

Chapter 5 is a natural extension of **Chap. 4** in terms of the application of non-mechanical means for polishing diamond and its composites. This chapter summarises the process of coupling thermal and chemical effects, with a concentration on the polishing of CVD diamond films. It is expected that by reading this chapter, the reader would understand, to a certain extent, the merit and limit of using thermo-chemical reactions, and thereby appreciate the vast flexibility of developing new polishing techniques for specific applications. For instance, in polishing a CVD diamond film, it is not favourable to apply large mechanical forces because the film can be fractured easily. That is why a thermo-chemical process, without mechanical, is more desirable.

Chapter 6 describes the application of high energy beams to the polishing of diamond, including laser and ion beams. In general, the polishing techniques with the aid of high energy beams can be regarded as a thermo-chemical process too, avoiding the application of mechanical forces, because physically, a high energy beam introduces very localized heating to result in high-temperature evaporation and oxidation, and hence to remove the surface material.

Chapters 7–9 discuss another variety of the techniques, the dynamic friction polishing (DFP), which integrates mechanical, thermal and chemical interactions into a single process. To reflect the depth of investigation into the DFP, the discussion is spread through three chapters, with **Chap. 7** presenting the process and modeling of the DFP, including the equipment required, estimation of interface temperature, polishing conditions and efficiency and the establishment of a polishing map for a superior surface finish; **Chap. 8** focuses on the understanding of material removal mechanisms and surface integrity characterisation; and **Chap. 9** addresses the application of the DFP and some issues to obtain ultra-smooth diamond surfaces.

As mentioned previously, the design of polishing techniques for diamond materials can vary, depending on the use of the various material removal mechanisms and on the requirement of specific application. The purpose of **Chap. 10** in this book is therefore to introduce briefly some other methods in addition to what have been described in the previous chapters. These include electric discharge machining, abrasive liquid jet polishing, aero-lap polishing and miscellaneous polishing.

Each polishing technique has its merits and disadvantages, and in many cases, has limitation in applications. Thus **Chap. 11** of this book is arranged to outline the applicability of the individual techniques. A general guide for their selection

is also given. Furthermore, the polishing of diamond materials is far from mature, and there are still many open problems to resolve. At the end of this chapter, therefore, some of such issues are highlighted for further investigations.

Overall, this book reviews in detail the polishing techniques available for diamond materials and discusses their merits, disadvantages and limits. It also tries to deliver the message that one can develop different kinds of polishing techniques by making use of the variety of the material removal mechanisms and by taking into account the specific requirements of the diamond materials to polish—mono/poly-crystalline, composites, CVD diamond films, geometries, etc.

The authors hope that this book provides some basics and serves as a useful source of information to engineers, production practitioners, researchers and students who need to select appropriate polishing techniques, or want to develop new polishing techniques for their specific applications.

July 2012

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Polishing of Diamond Materials

Mechanisms, Modeling and Implementation

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2013, XI, 174 p. 49 illus., 2 illus. in color., Hardcover

ISBN: 978-1-84996-407-4