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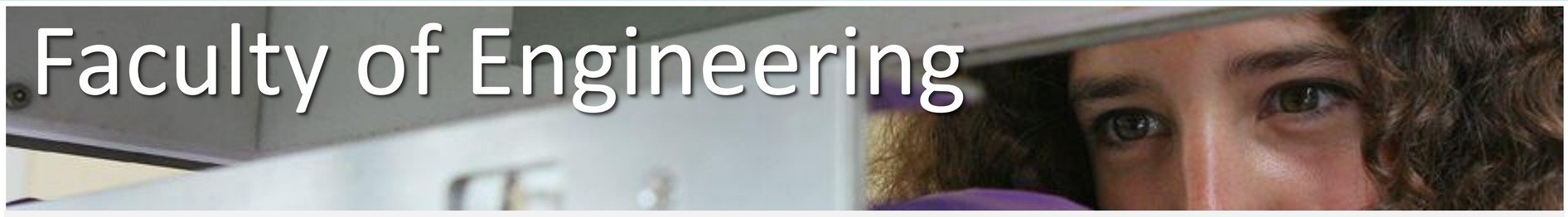


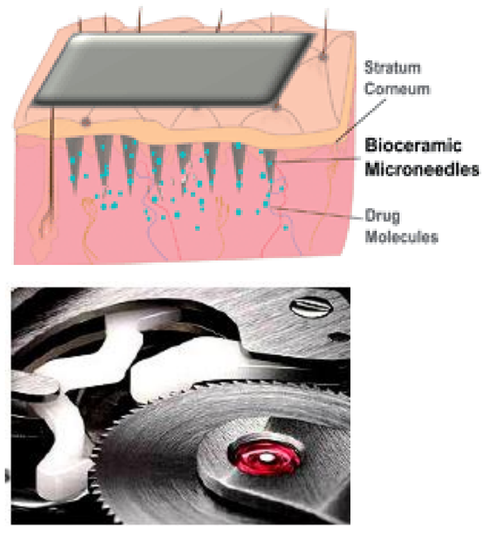
The Hybrid Machining of Ceramic
The choice of production stage

euspen

Abstract

The demand for micro products has increased gradually since last decades in various areas, requiring the development of micro manufacturing processes. Micro manufacturing is characterized by the size of functional features (less than 10 mm), a high precision, a good surface finishing and complex parts in a wide variety of materials. The Traditional Machining Processes (TMPs) are intensively used to produce micro-components, but the minimum feature size they can produce is limited [1]. In parallel, the Nontraditional Machining Processes (NMPs) were developed to manufacture micro component of a few microns, but the processing times are slower [2]. Hybrid Machining Processes (HMPs) were introduced to address the demand to increase production with an enhanced quality for difficult-to-machine materials such as ceramics [3].

The HMP considered is a combination of micro-milling and laser machining which is developed to machine ceramic materials. This HMP may be carried out at different stages in the ceramic production. The goal is to determine the most attractive production stage in ceramic machining with this HMP.

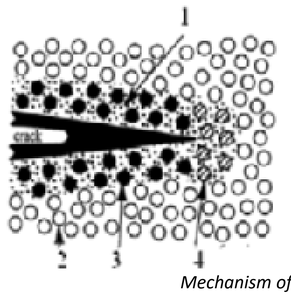


Examples of micro products[4]

Material

- Y-TZP ceramic
- Transformation toughening

CRIBC members of EMRA

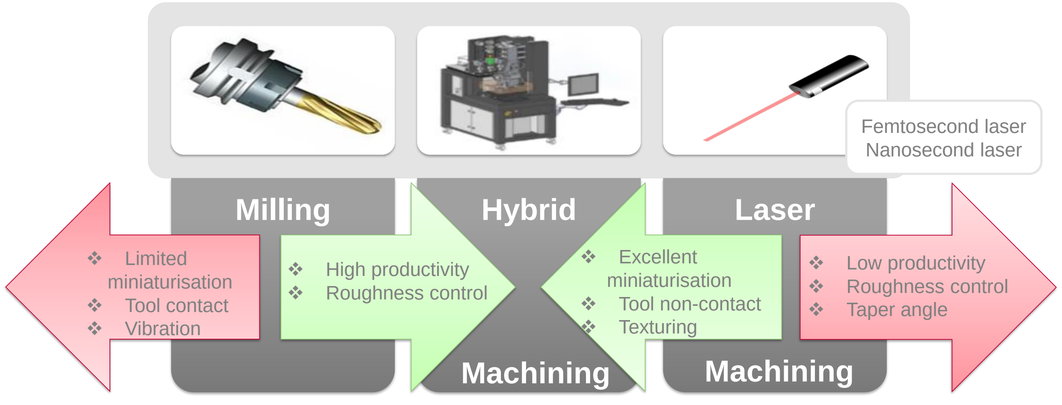


1. Processing zone
2. Unstable tetragonal particle
3. Stable monoclinic particle which transformed
4. Tetragonal particle during processing

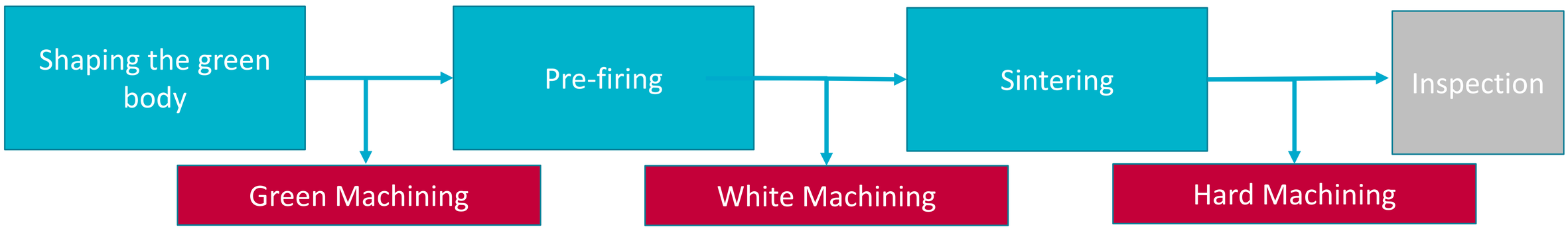
Mechanism of transformation toughening [5]

Hybrid Machining

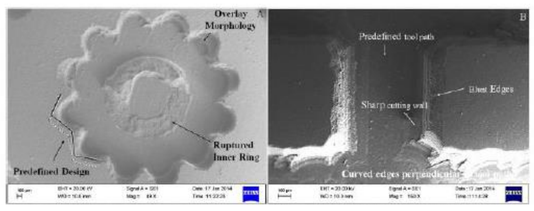
OPTEC



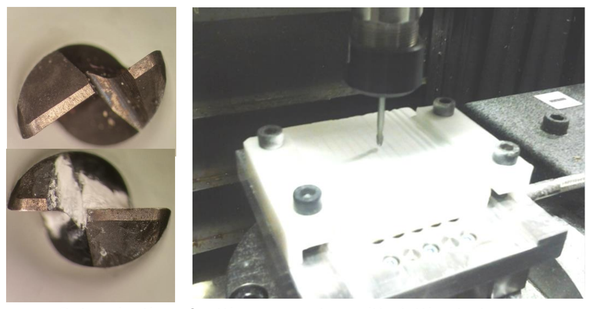
Ceramic production with several production stage



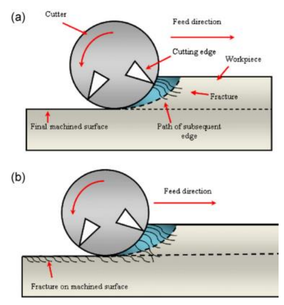
Milling



SEM micrograph of micro-patterned object by (A) and (B) CNC milling [7]

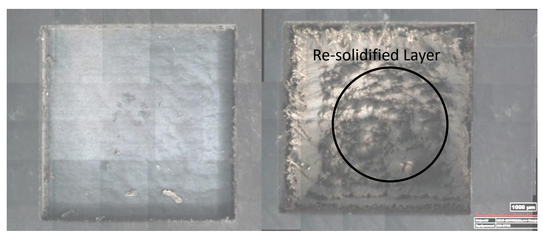


Determination of cutting parameters with slotting tests

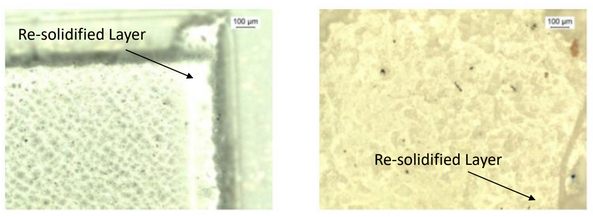


Influence of feed per tooth in hard machining
(a) low feed per tooth (b) high feed per tooth [8]

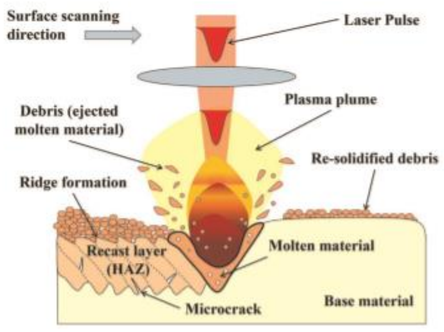
Laser Machining



Experimental test with nanosecond source



Experimental test with (a) nanosecond source and (b) femtosecond source



Interaction phenomena during low scan speed machining [9]

Conclusion

	Micro-milling	Laser Machining
Hard Machining	−	−
White Machining	+ +	− −
Green Machining	+	+

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