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SHORT COMMUNICATION

Ultrasonic Machining as an Aid to Ceramic Etching

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ABSTRACT

Ceramics are difficult to etch. Their chemical inertness makes them very stable and often hot etching techniques are required to obtain their microstructures. This communication reports a technique developed to ease the process of ceramic etching.

1. INTRODUCTION

Ceramics have a wide variety of applications ranging from simple insulations to very complex surgical implants like artificial teeth, bones, joints, etc. The new class of ceramics termed as the advanced ceramics also find numerous engineering applications as in internal combustion (IC) engines, thermal barrier coatings, tougher metal cutting tools, etc due to their high strength and toughness properties. The strength and mechanical behaviour of all these ceramics are dependent on their microstructures. Hence a study of the microstructure is essential and indispensable to attain the desired performance level of any ceramic material.

2. EARLIER ETCHING METHODS

For microscopic observation, the material has to be polished and etched. Etching is necessary to selectively attack and reveal the grain boundaries. Since ceramics are chemically inert, they are not easily attacked by the etchants. Often hot etching is required to obtain satisfactory microstructures. For example, alumina is etched[1] at 218 °C, magnesia with boiling phosphoric acid[2], silicon carbide[3] at 650 °C, silicon nitride[4] at 300 °C, yttria[5] at 300 °C and zirconia[6] at 500 °C.

3. CURRENT PROCEDURES

Due to its high strength, high toughness[7] and high etching temperature[6], zirconia was chosen as a representative of the 'difficult to etch' variety of ceramics. Since etchants attack the grain boundaries only chemically, ultrasonic machining was chosen to introduce a mechanical attack on the grain boundaries. In an ultrasonic machine, the work piece is subjected to repeated abrasive action of an abrasive slurry being directed towards the work by an ultrasonically vibrating tool[8]. The continuous acti~~ of the abrasive slurry is expected to attack and weaken the grain boundaries mechanically, thereby, facilitating easy chemical etching.

Two specimens of yttria-stabilised tetragonal zirconia polycrystals[9] (YTZP) were obtained from Powder Metallurgy Laboratory, IIT, Madras. Both specimens were ground flat with a diamond wheel. Specimen I was directly hand-lapped with diamond paste and etched. Specimen II was subjected to ultrasonic machining in a horizontal type Lehfeldt-Diatron IC make ultrasonic machine using mild steel tool and boron carbide slurry. Then this specimen was also hand-lapped with diamond paste and etched. In both cases, the etchant used was made up

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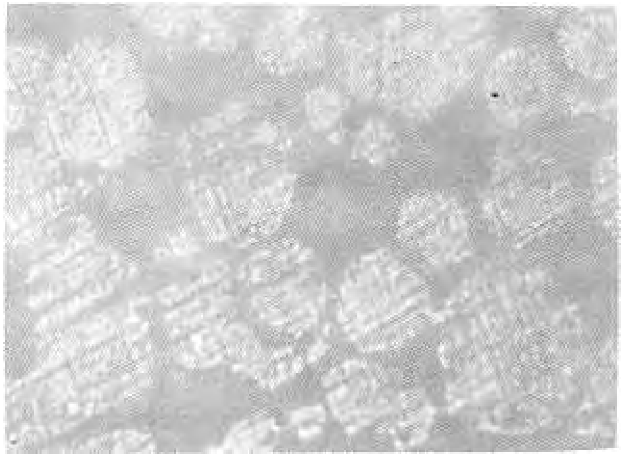

Figure 1. Microstructure of specimen II of YZTP (×250) subjected to ultrasonic machining and etched.

of 45 per cent H_2O, 45 per cent HNO_3 and 10 per cent HF by volume (prepared in a PVC beaker and swab-etched by holding with tongs, since HF is prone to attack skin and glass).

4. RESULTS

Specimen I was not at all attacked by the etchant. Specimen II which was subjected to ultrasonic machining was easily etched at room temperature itself Figure 1 shows the microstructure of specimen II. The platelets are of tetragonal phase, the white etching portions are of monoclinic phase[10] and the black spots may be due to grain pull out during grinding or due to over etching.

5. CONCLUSIONS

From the above discussion, it is clear that zirconia which was previously etched at 500 °C can now be etched at room temperature itself. Since there is no chemical reaction involved and as this technique produces only a mechanical weakening of the grain boundaries, it is obvious that any ceramic can be easily etched at room temperature (by the same etchant used for hot etching) if the specimen is subjected to ultrasonic machining. The proportion of the abrasive in the slurry, the ultrasonic machining time, the composition of the etchant and the duration of etching are the parameters that can be varied to suit the need for a particular ceramic.

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