Exploratory Study of Nano Ultrasonic Machining Process

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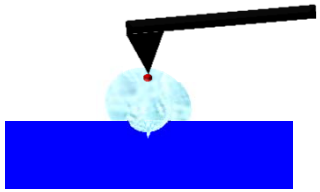
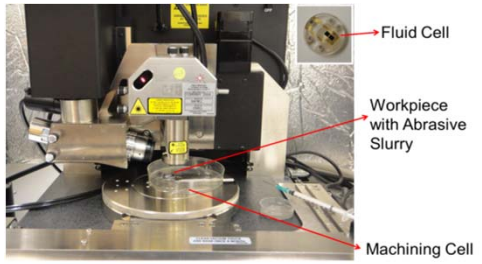




Process Feasibility Study

Theoretical and Experimental Studies have been conducted

Maximum force $P_m = \left[\left(125\pi^3/48\right)^{1/5}\left(E_w/k\right)^{2/5}\rho_a{}^{3/5}\left(d_a/2\right)^2\right]V_I{}^{6/5}$

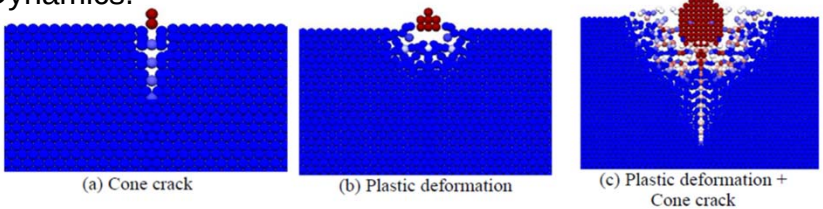
Critical load $P_c = K_C^2\phi\frac{d_a}{2}{}^{k}/_{E_w}$

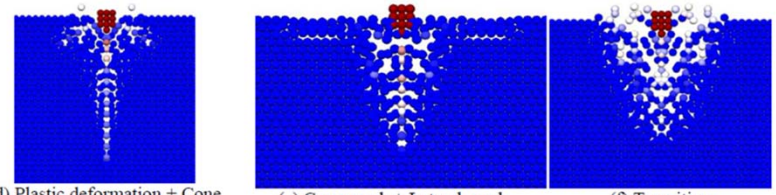
When this critical value (P_c) is exceeded, material removal happens

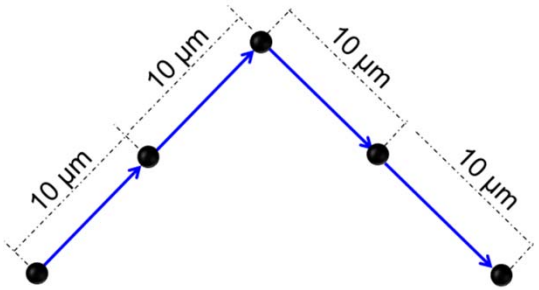
Workpiece Material	Poisson's ratio v_w	Young's Modulus E_w ($N/m^{2*}\ 10^{10}$)	Fracture Toughness K_c ($MPa*m^{1/2}$)	Maximum Load P_{max} ($N*10^{-12}$)	Critical Load P_c ($N*10^{-12}$)	Feasibility
Soda-lime glass	0.22	7.07	0.74	1.573	1.148	Yes
Silicon	0.3	18.8	0.7	2.25	0.4197	Yes
Borosilicate glass (Pyrex)	0.198	6.27	0.63	1.503	0.9328	Yes
SiO_2	0.167	7.25	0.79	1.587	1.2794	Yes
Silicon carbide (SiC)	0.17	45.47	2.8	2.972	3.352	No
Zirconia	0.25	21	6	2.334	2.8152	No

Process Mechanism Study

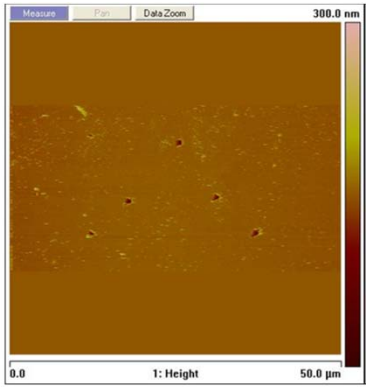
Material removal mechanism was studied using Molecular Dynamics.



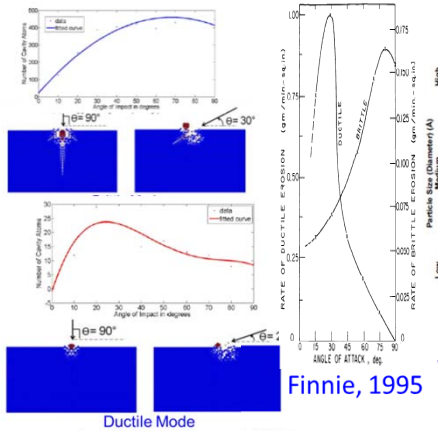




Pattern Design



Machined Pattern



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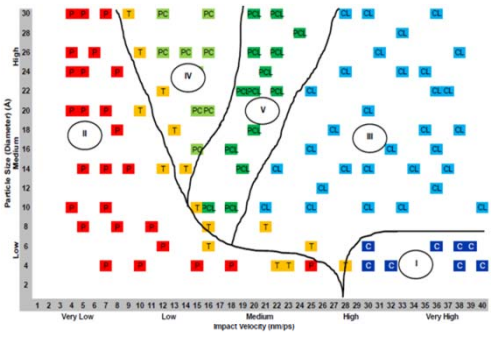

Wear Map showing Material Removal Regimes

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