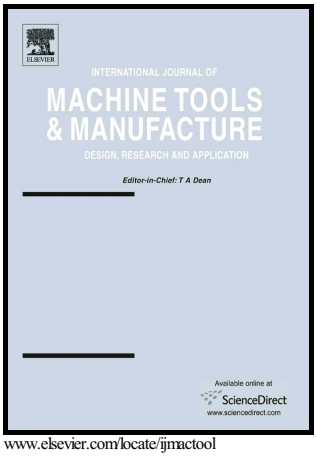
Study on ductile mode machining of single crystal silicon by mechanical machining

Dae-Hee Choi, Je-Ryung Lee, Na-Ri Kang, Tae-Jin Je, Ju-Young Kim, Eun-chae Jeon



www.elsevier.com/locate/ijmactool

PII: S0890-6955(16)30141-9
DOI: http://dx.doi.org/10.1016/j.ijmachtools.2016.10.006
Reference: MTM3204

To appear in: *International Journal of Machine Tools and Manufacture*

Received date: 16 August 2016
Revised date: 31 October 2016
Accepted date: 31 October 2016

Cite this article as: Dae-Hee Choi, Je-Ryung Lee, Na-Ri Kang, Tae-Jin Je, Ju Young Kim and Eun-chae Jeon, Study on ductile mode machining of singl crystal silicon by mechanical machining, *International Journal of Machine Tool and Manufacture,* http://dx.doi.org/10.1016/j.ijmachtools.2016.10.006

Study on ductile mode machining of single crystal silicon by mechanical machining

Dae-Hee Choi[a,b], Je-Ryung Lee[b], Na-Ri Kang[c], Tae-Jin Je[a,b], Ju-Young Kim[c,*], Eun-chae Jeon[a,b,*]

[a]Department of Nano Mechatronics, University of Science and Technology, Daejeon, 34113, Korea

[b]Department of Nano Manufacturing Technology, Korea Institute of Machinery and Materials, Daejeon, 34103, Korea

[c]School of Materials Science and Engineering, Ulsan National Institute of Science and Technology, Ulsan, 44919, Korea

jeonec@kimm.re.kr
juyoung@unist.ac.kr

[*]Corresponding author.

Abstract

Nano patterns on single crystal silicon are generally manufactured by photolithography, which can form limited cross-sectional shapes such as U-shapes or rectangular channels. Though V-shaped patterns are widely used in the optical industries because they concentrate light, they are challenging to manufacture by conventional photolithography. Mechanical machining is useful in manufacturing various kinds of cross-sectional shapes including V-shapes with various apex angles, but is hard to apply to single-crystal silicon due to its brittle fracture. Here we suggest a novel way of mechanical machining of single-crystal silicon that suppresses brittle fracture below the critical point (the ductile-brittle transition point) as determined by nano scratch testing. We find that the first drop point of the cutting force corresponds to a critical point and define the critical forces as the thrust force and the cutting force at the critical point. The critical forces are varied by the applied force per unit length, which is the possibility that the cutting tool interacts with mechanically weak atomic bonds. When the applied force per unit length is zero (a general condition of mechanical machining), the cutting speed does not affect the variation of the critical forces or the quality of the machined pattern. Based on analysis of the experimental results, we suggest that the single-crystal silicon can be mechanically machined without brittle fracture at high cutting speed if the thrust force is smaller than the critical force of zero applied force per unit length.