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SURFACE PROPERTY MODIFICATION OF SEMICONDUCTORS BY FLUID ABSORPTION

UNIVERSITY OF ILLINOIS AT CHICAGO

S. Danyluk

Objectives

. Lubricated Cutting (wafering)
  - laboratory simulation
  - mechanism
  - model

. Residual Stresses in Sheet
  - Develop Interferometry Technique
  - Apply to EFG and WEB

Lubricated Cutting in Simulated Laboratory Experiments

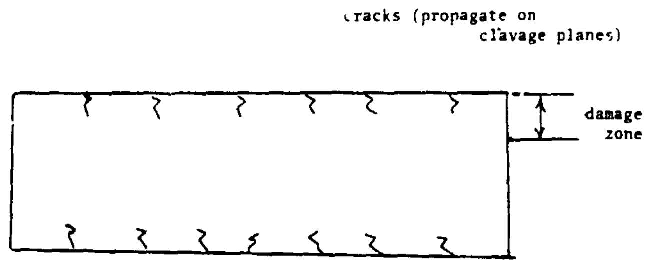
Load, Temperature, Fluids

- Surface Morphology
- Hardness
- Wear rate
- Depth of Damage

Mechanism

Model

Silicon Wafer



plasticity(?)

.due to high compressive stresses

. at crack tips

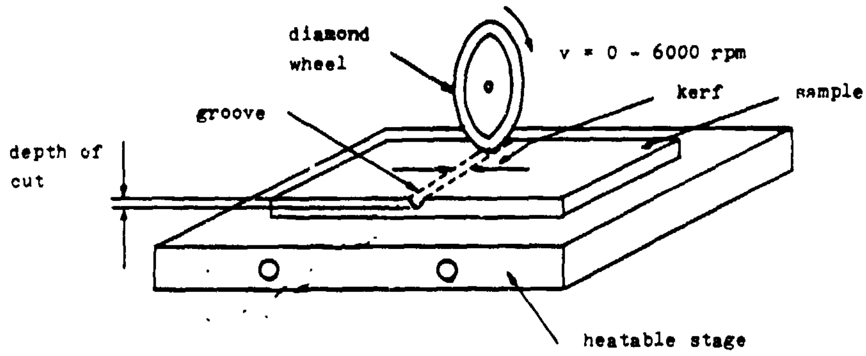
. Simulate Damage

dicing (OD sawing)

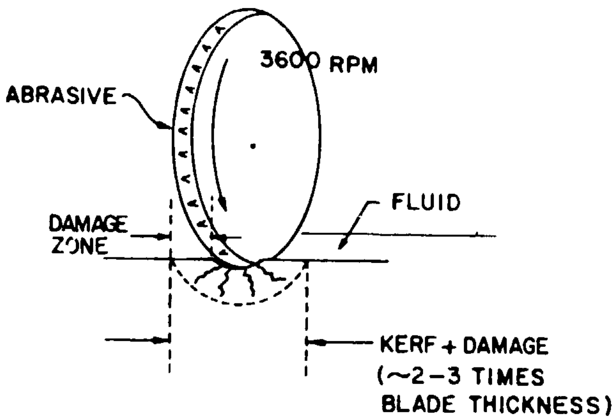
indentation (Vickers dia)

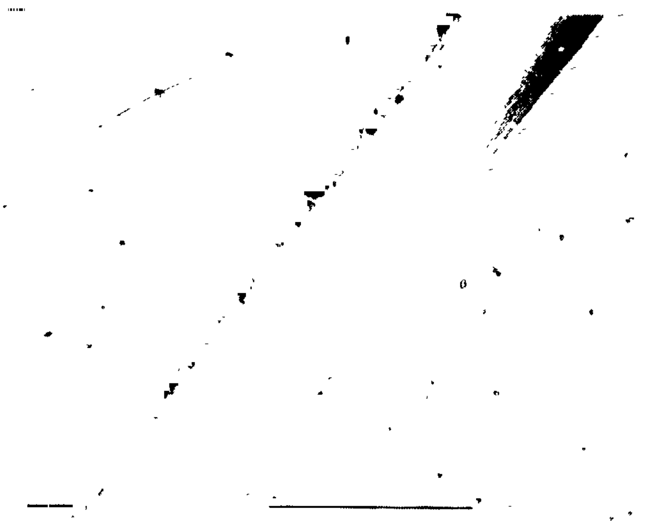
Identify critical parameters

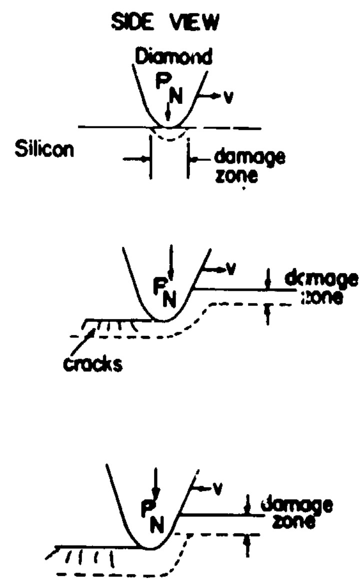
Load
fluid
temperature

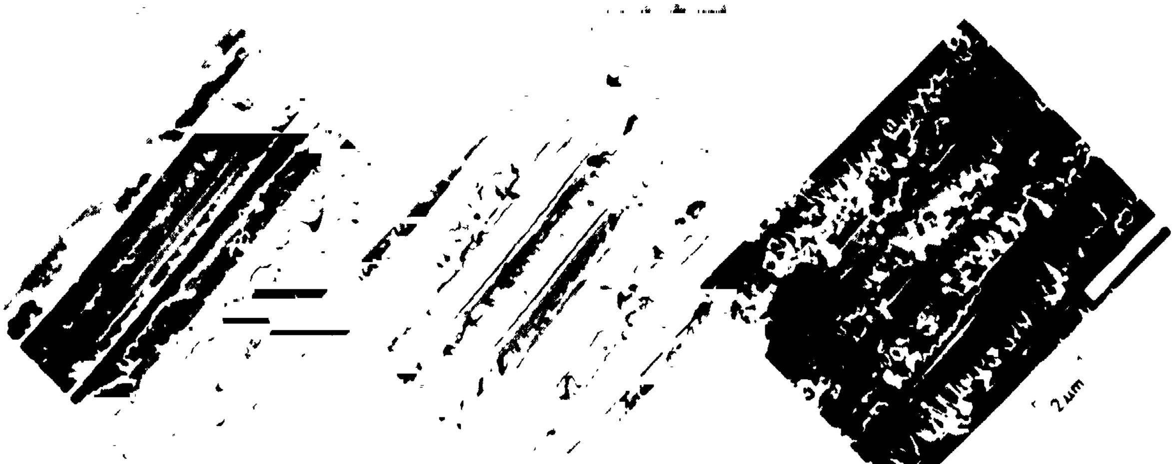


OD Sawing (Dicing)

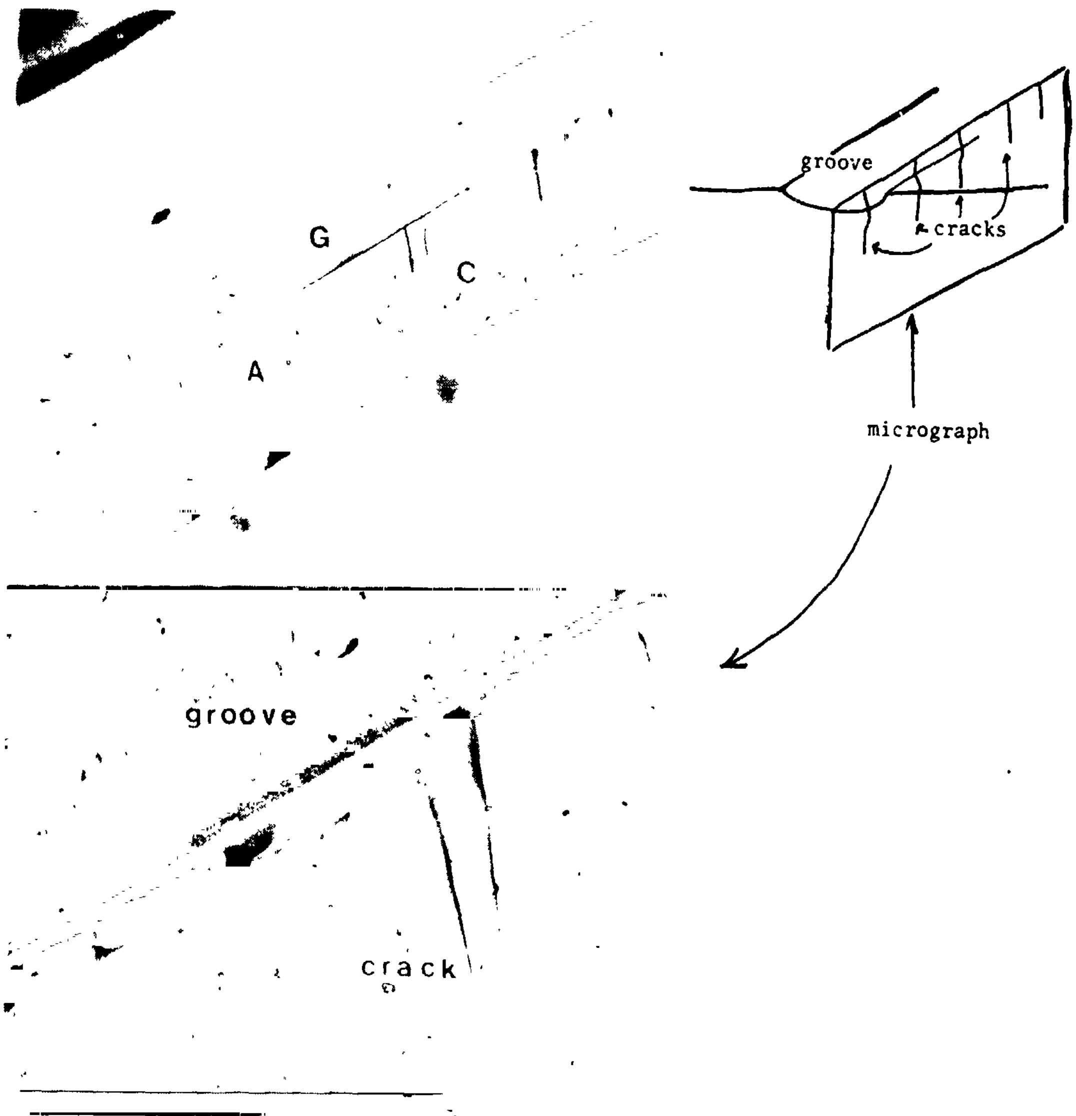








Examples of Cracks at the Bottom of Grooves



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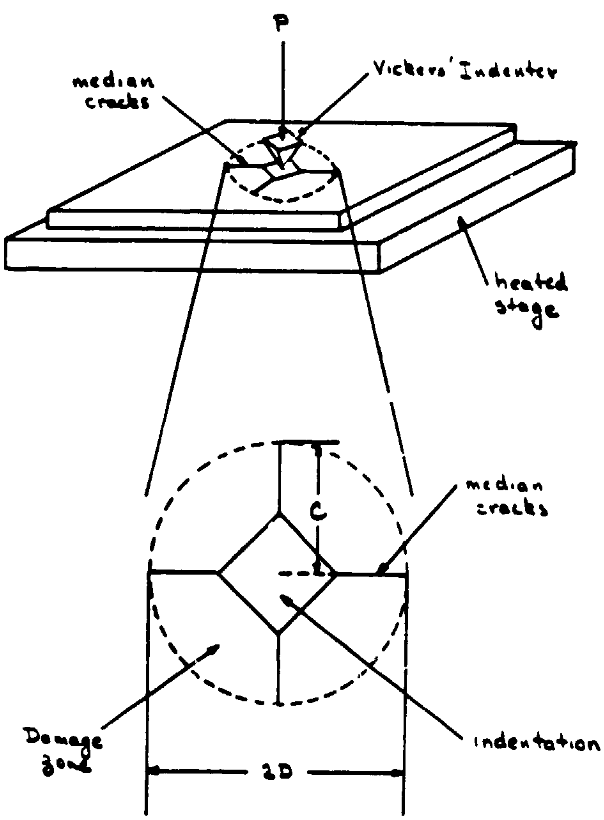
Summary of High-Speed, Elevated Cutting

Deformation Mode	Cracks at Bottom of groove
	Plasticity

Fluids, Temperature--- influence surface morphology



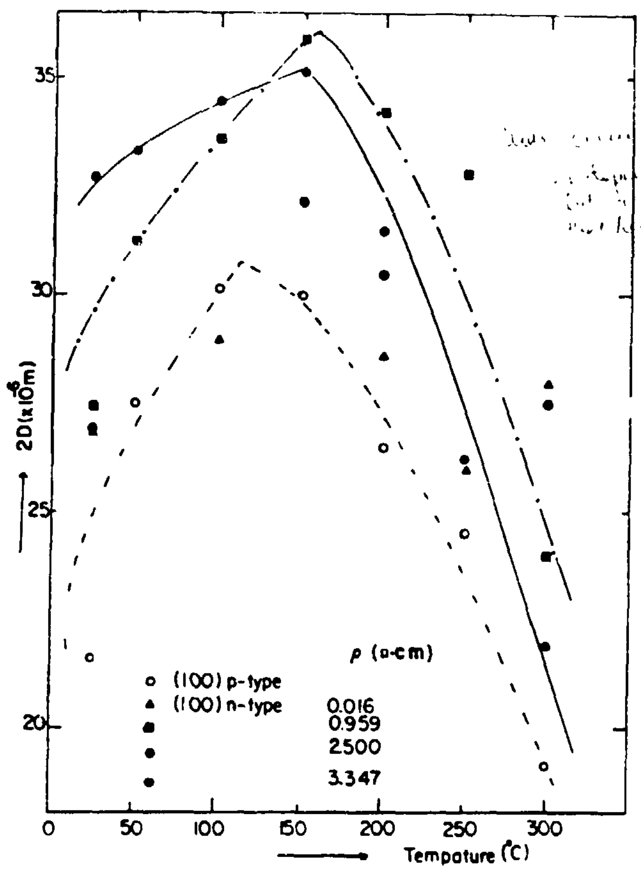
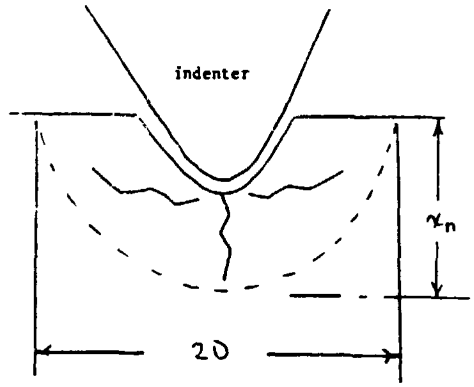


Figure 36. Damage size(2D) vs. indentation temperature for p-type and n-type Cz silicon. The indentation load was 0.49N. The n-type silicon had resisistivites of 0.016, 0.959, 2.5, and 3.347Ωcm.

Indentation Model



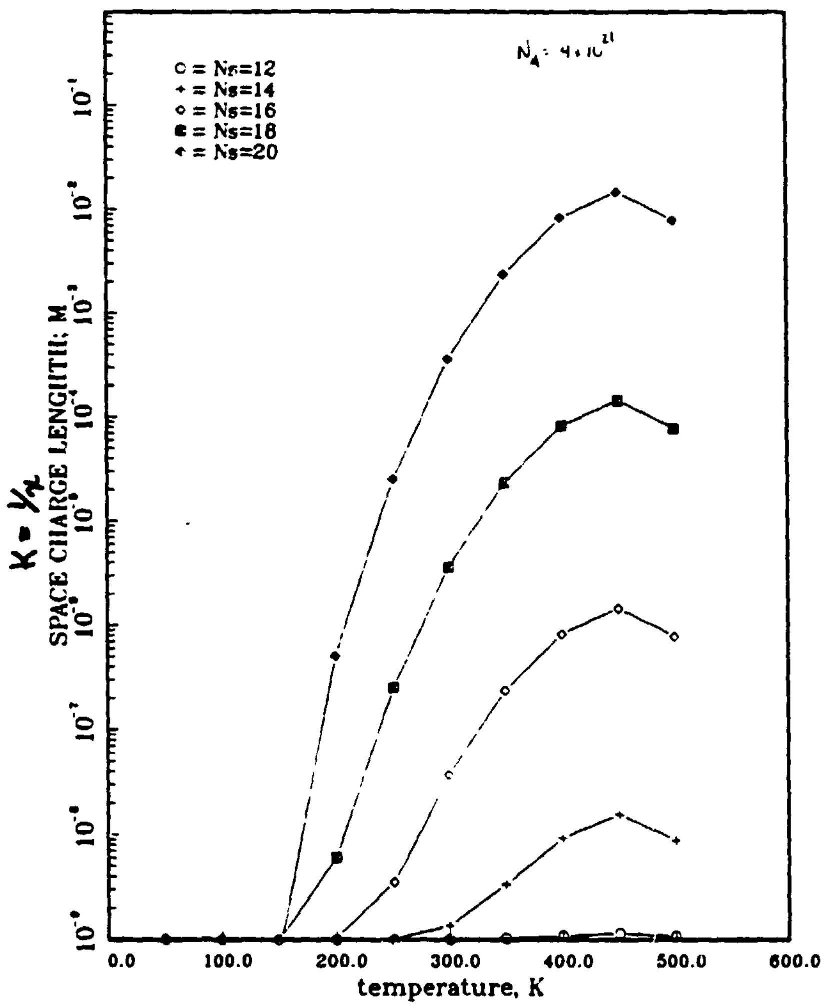
$2D \propto X_n$ — at low P, space charge fields influence damage

$$X_n = \frac{N_s}{N_D}\left[\frac{e^{\left(\frac{\mu_e - E_{ss}}{kT}\right)}}{1+e^{\left(\frac{\mu_e - E_{ss}}{kT}\right)}} - 1\right]$$

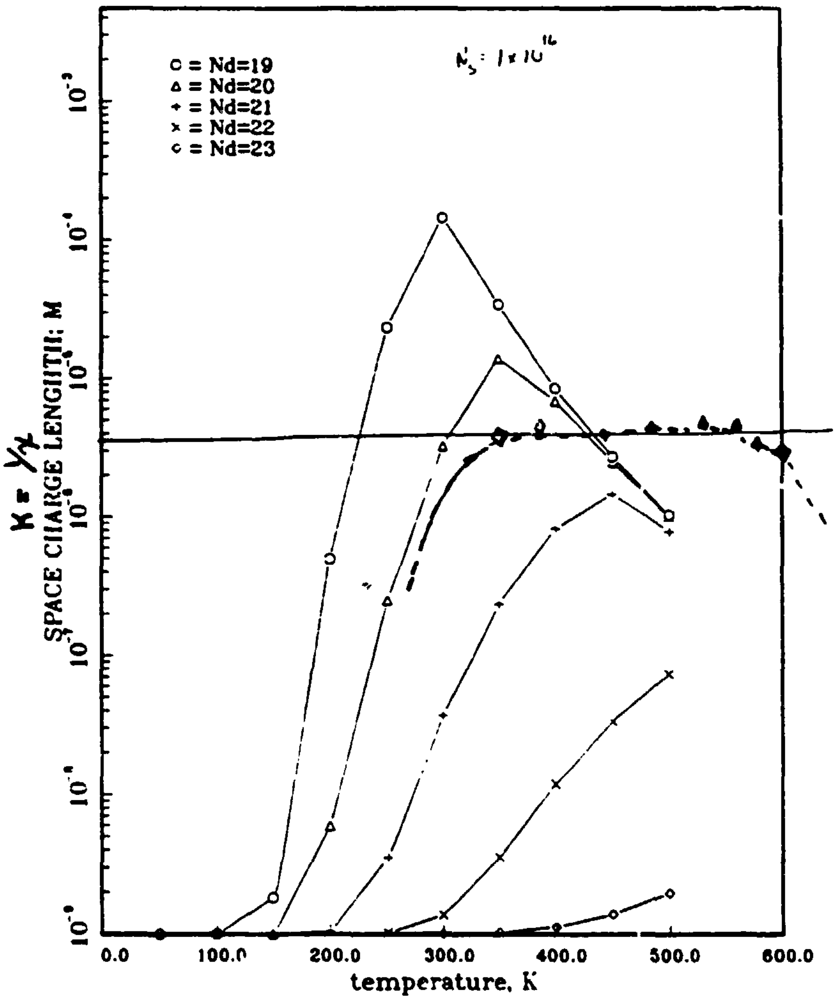
- N_s - finite number of surface states
- N_s, E_{ss} not known but extracted from expt.
- μ_e, electrochemical potential

$2D = f(N_D, N_s, E_{ss}, T)$

Space Charge Length as a Function of Temperature



Space Charge Length as a Function of Temperature



Summary of Indentation Model

2D and x_n exhibit maximum at 150C

$N_s = 10^{16} - 10^{18}/m^2$

$E_s = 0.79$ eV

Doping level influences 2D

Predict T, N_D variation with 2D

Summary of Silicon Results

. Wear rate

. Ethanol - highest

. air - lowest

. Damage

.load — plasticity, p 100gf

.load — cracks, p 200gf

.temp

cracks, damage decreases at T 250°C

. bulk doping

. fluid

Conclusions

Mechanisms of Wear

- Wear rate and damage includes: cracks and plasticity
- Laboratory simulation tests provide guidance in modifying industrial practices.
- Wear rate may be optimized and damage may be minimized

  Load (below 0.98N (100fg)
  Fluid (alcohol-based vs. water-based fluids)
  Temp (200-300°C)

- Model allows parameters to be identified and range to be extrapolated.
- Unresolved problems: Impact, fatigue

Residual Stresses

- Interferometry is a promising NDT technique for sheet geometries
- Edges - compressive
  Center - tensile
- EFG - v_{growth} = 2 cm/min - σ_{RS} = ±10MPa

  WEB - v_{growth} = cm/min - σ_{RS} = ±1 MPa
- Unresolved problems: anisotropy of E, ν
  dendrite geometry