Ceramic Wafer Breaker

Sponsor: Dade Behring

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Agenda

- Project Overview
- Problem Review
- Problem Statement
- UDesign
- Concept Design and Development
- Preliminary Testing and Design
- Prototype Testing
- Path Forward
The Current Process

- 4” x 4” wafer broken into 8 - 2”x1” pieces
- Breaking order
  - Breaks 2 wafers (4”x1”)
  - Breaks 1 wafer (2”x1”)
- Breaking along laser scored line
- Automatically inserted into breaking device
- Used to test body’s electrolytes
Problems with Process

- Shattering may occur at end of entire process
- Alignment materials wear due to ceramic rubbing
- Laser scoring completed at various depths
- Lacking data to determine best breaking location, applied force and clamping location
- About 95% efficiency yield
To develop an offline testing device to better understand the ceramic wafer breaking process through the use of data collection, multiple mounting configurations and force application locations.
Product Value

- Gain understanding of breaking and force associated
- Investigate effects of various score depths
- Qualify laser scoring vendors
- Improve quality of wafer breaking process
UDesign Process

- Used to facilitate design process
- Identify customers and rank their wants
- Develop metrics to quantify wants
- Use target values to qualify metrics
- Concept selection based on comparison to target values
Customers and Wants

1. Jim Kegelman and Scott Brown
2. Derrick Tempraseut
3. Operators

Customer Wants

- Safety
- Data Collection
- Durability
- Breaking Variability
- Inc. Process Understanding
- Consistent
Metrics and Target Values

- # motors/actuators: No more than 2
- # different configurations: At least 4
- Material hardness: Lasts at least 1 year
- Feedback accuracy: Within 0.02 pounds
- Meets Dade safety: Complete Compliance
- Captures max. force: Yes
Concept Generation Summary

- Initial concepts did not satisfy all wants
- Concept shortcomings initiated refinement of system requirements
Concept Subsystems

Final Concept

- Allow for multiple breaking configurations
  - X/Y Table

- Provide accurate force feedback
  - Load Cell and Panel Meter

- Be powered by only one actuator
  - Robocylinder
Final Concept:

- Fixed actuator
- Table moves wafer in x and y direction
- Allows for variable breaking orientations and locations
- Load cell outputs max force

Detailed Drawing of Base Plate

Robocylinder (Programmable Linear Actuator)

Cylindrical Load Cell with Digital Panel Meter

Base Plate: Multi-level Aluminum plate that houses ceramic wafers for clamping and breaking

Final Actuator Position

X-Y Table: Allows for precise wafer positioning under fixed actuator
Reality Check

- Safety
  - Safety enclosure designed and warning labels

- Data Collection
  - Peak force displayed by panel meter

- Variable Force Application Location
  - Flexible design allows load to be applied at multiple positions

- Durability
  - Vulnerable machine parts faced in ceramic to prevent groove formation

- Increase Process Understanding
  - System allows for optimization of the breaking process and ability to test product specs

- Versatility of Design
  - Actuator Velocity, Actuator End Pieces, Clamps, Materials, Breaking Configuration
Design and Development

- Parts Selection
- Preliminary Testing
- Cost Analysis
- Prototype Development
Selection of Necessary Parts

- **Actuator**
  - Provides linear motion for wafer breaking

- **Load Cell with panel meter**
  - Load cell measures and relays force to panel meter
  - Panel meter displays peak force

- **Automated Motors**
  - Allows for precise wafer positioning

- **Toggle Clamps**
  - Securely hold wafers in place for breaking
Preliminary Testing and Results

- **Preliminary Testing**
  - No available data on breaking force
  - Preliminary testing necessary to get approximate force values for parts selection

- **Testing Results**
  - Breaking forces ranged from 1 to 8 pounds
  - Force approximately inversely proportional to displacement from score line
Cost Analysis

Total System Cost $4179

- Robocylinder, Controller and Software ($1125)
- Cylindrical Load Cell ($535) with Digital Panel Meter ($245)
- Miscellaneous Materials ($500)
- X-Y Table (Provided By Sponsor)
- Automated Motors and Software ($1754)
Component Qualification

- **Position**
  - Robocylinder provides accurate and reliable positioning of actuator within 1 mm
  - X-Y table positioning is accurate to one-thousandth of an inch

- **Force**
  - Load cell is accurate to 0.02% of each reading

- **Feedback**
  - Panel meter outputs peak force but sampling rate insufficient
  - For testing incorporated LabView for data collection
Experimental Design

- Response Variable
  - Force

- Factors Varied
  - Score Depth
  - Overhang
  - Distance

- Factors Held Constant
  - Actuator Velocity – used 1mm/s during impact
  - Actuator End Pieces – point application
  - Clamps – U-shaped clamps
  - Materials – ceramic faced aluminum for stoppers
  - Breaking Configuration – break 4 (4” x 2”) then break 1 (1” x 2”)
Wafer Testing (force vs. score depth)

- First break: shallow score depth required less force
- Second break: score depth was not significant
- With 6/1000 depth, shattering rarely occurred
- Bending more pronounced in deeper score depth
Wafer Testing (force vs. overhang)

- Fixed score depth and breaking configuration
- Varied:
  - Breaking location
  - Overhang
Wafer Testing (force vs. overhang)

- Reduced force with smallest overhang
- With increased distance, difference in force not significant
- Increased shattering incidence with increased overhang

![Force vs. Overhang Graph](image)
Shattering Results

- Shattering rarely occurred with 6/1000 score depth
- Could be attributed to processing differences
- Definite relationship between shattering and overhang

**Score Depth vs. Shattering**

- Percent Lost
  - 6/1000: 0.0%
  - ~10/1000: 22.2%

**Overhang vs. Shattering**

- Percent Lost
  - 0.025 in.: 16.2%
  - 0.125 in.: 21.0%
  - 0.250 in.: 35.3%
Path Forward

- Instruction booklet for machine setup
- Operator’s manual
- Cad Drawings
- Upgrade panel meter
- System will not be reproduced on large scale
Additional Testing

- Look more into effect of overhang
- Determine effects of different actuator velocities
- Test with different clamps
- Test with different end pieces
In Loving Memory of Panel Meter #1 and Load “LC FA-25” Cell