

# Robotic Protein Crystal Streak Seeding Using Silicon Microtools

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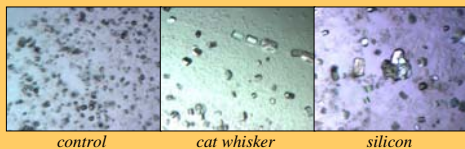
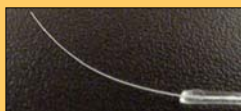
## Introduction

**Goal:**  
Automated streak seeding of 96-well plates

- Problems:**
- Tools for seeding
  - Crystal detection in image
  - Droplet location in image
  - Robotic streak seeding system

## Streak Seeding With Silicon

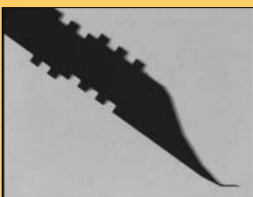
- A cat whisker is normally used for manual seeding by crystallographers
- Cat whiskers are not rigid
- Difficult to:
  - Track in image
  - Locate tip
  - Detect contact
- Silicon microtools produce good seeding results



control      cat whisker      silicon

## Design and Fabrication

- Created CAD designs of over 30 different shapes and sizes of *microshovels*
- Used MEMS technology (photolithography, DRIE) to manufacture over 100 tooltips out of silicon wafers
- Microshovels used for both streak seeding and crystal mounting



## Seeding Steps

1. Wash tool in bucket



2. Detect & poke crystals



3. Streak through droplets



## Crystal Detection



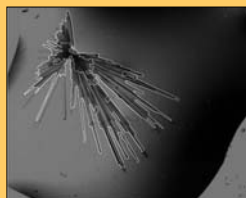
2a/  
Detect edges in image



2b/  
Fill in holes and threshold



2c/  
Clean up using morphological operators



2d/  
The original image with the boundary of detected crystals overlaid

## Droplet Location



3a/  
Successful detection of a small offset



3b/  
Successful detection of a large vertical offset

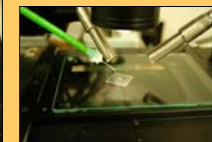
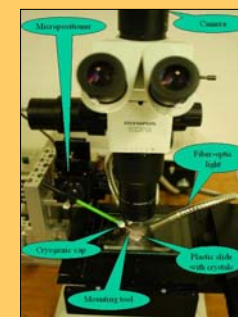


3c/  
Successful detection of a large horizontal offset



3d/  
Successful detection of a large diagonal offset

## Prototype Microrobotic Streak Seeding System



## Sample Seeding Run



1. Initial image



2. Detected crystals



3. Probe poking crystal 1



4. Probe poking crystal 2



5. Droplet center located



6. Streaking through droplet

## Conclusions

- Progress toward automated crystal seeding
- Designed and manufactured new tools to address limitations of traditional cat whiskers
- New tools can be used for both manual and automatic manipulation
- Built a functional prototype of a microrobotic seeding system