Evolving a Classification Tool

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2008 "HUMIES" AWARDS FOR HUMAN-COMPETITIVE RESULTS

Monday, July 14, 2008
Atlanta

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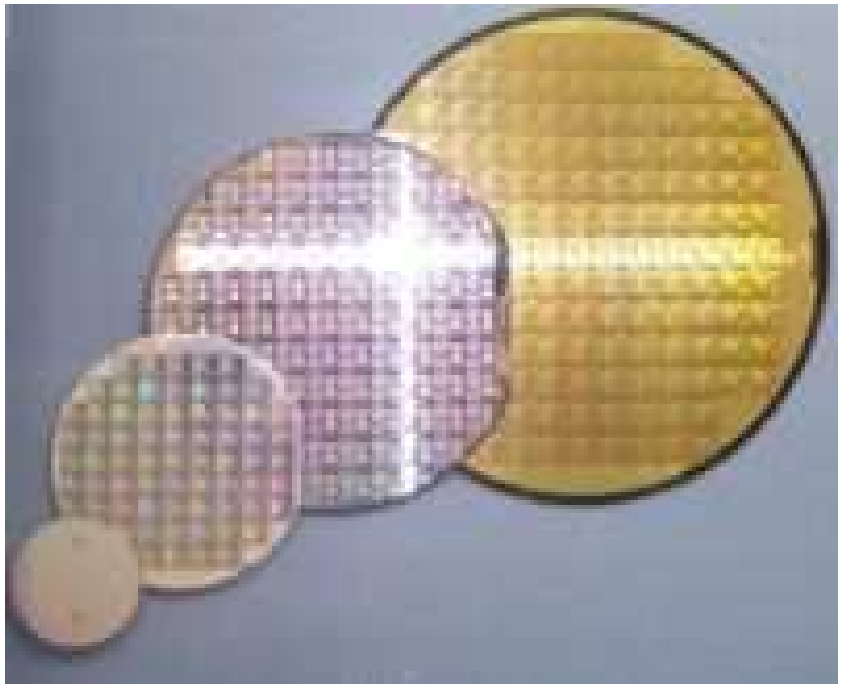
Evolving an automatic defect classification tool

Proceedings EvoWorkshops 2008, pp. 194-203

Background

- Applied Materials Inc.
  - Production of Semiconductors (fabs)
  - 80% market share (several billion $)



Wafer

Fab: Customer's wafer fabrication facility

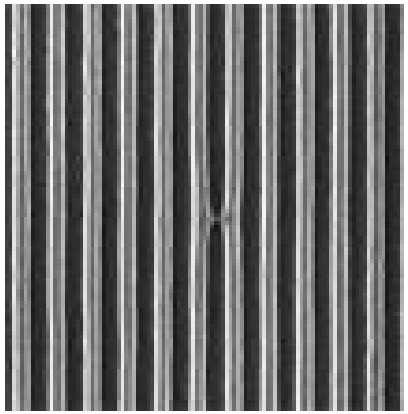
Background

- AMIL – Applied Materials Israeli Division
  - PDC – Process Diagnostic & Control
  - SEMVision product holds 70% share of Defect Review market (~0.5 billion $)
  - Benchmark: SEMVision ADC tool
  - Current product based on RBFN Classifier

SEMVision (Scanning Electron Microscope)

Automatic Defect Classification (ADC)

Feature Extraction → **Classification** → **Class (Defect Type)**



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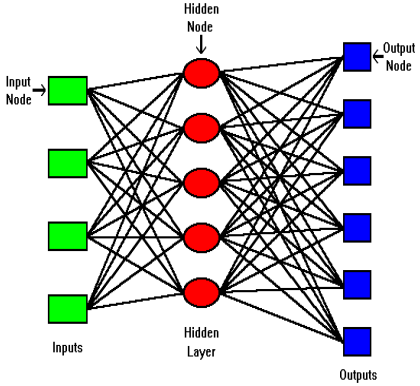
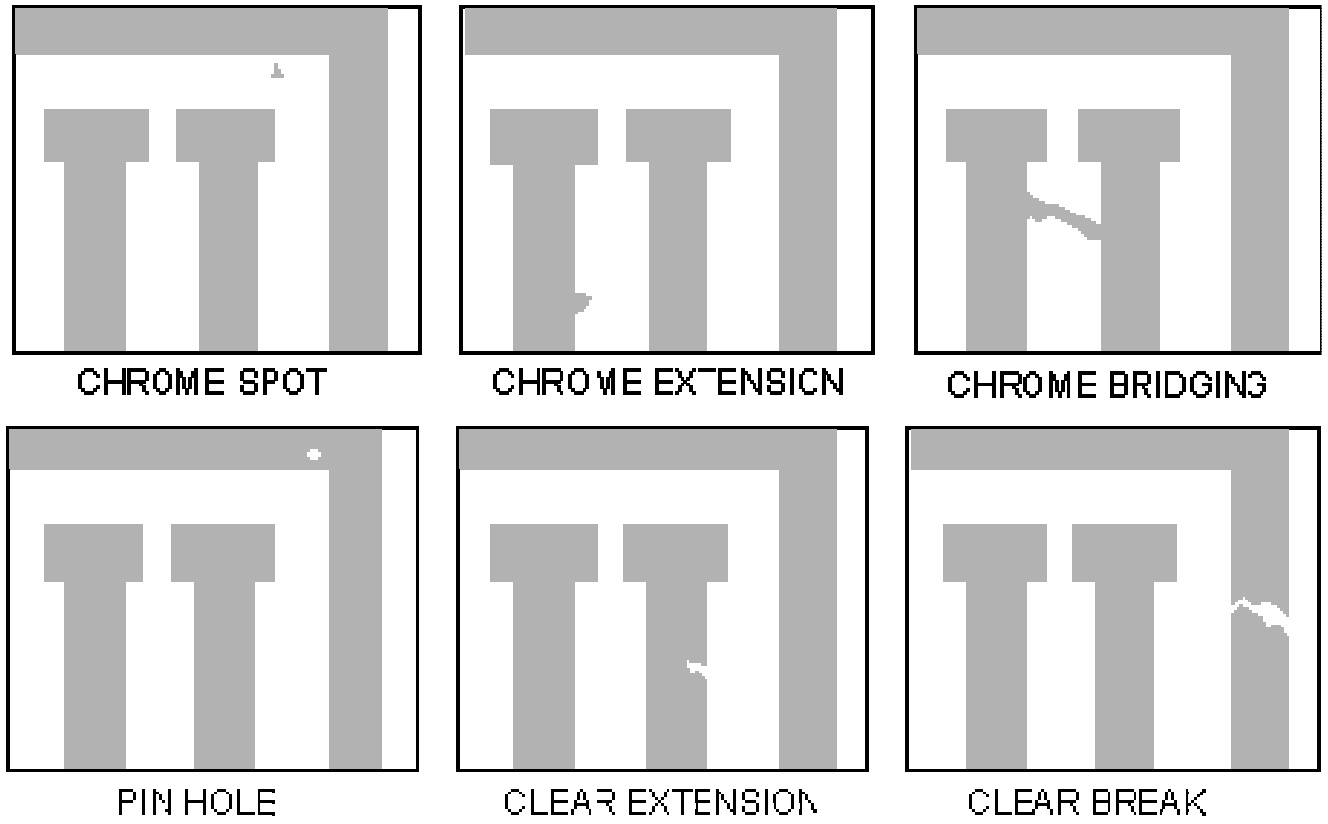


⇨ **Pattern Defect**

ADC (cont'd)

ADC **is a key step in the identification of the root cause of manufacturing problems**



EXAMPLES OF DEFECTS

Guidelines

- Maximize classification rate
- Anytime algorithm
- Generic model
- Reduce Complexity
- Robust solution: ***Remove human from loop***

The ADC Challenge

- Overcome problem of sparse data
- Explore new and obsolete defects
- Automated process, no human intervention (/interference…)

Baseline (Human)

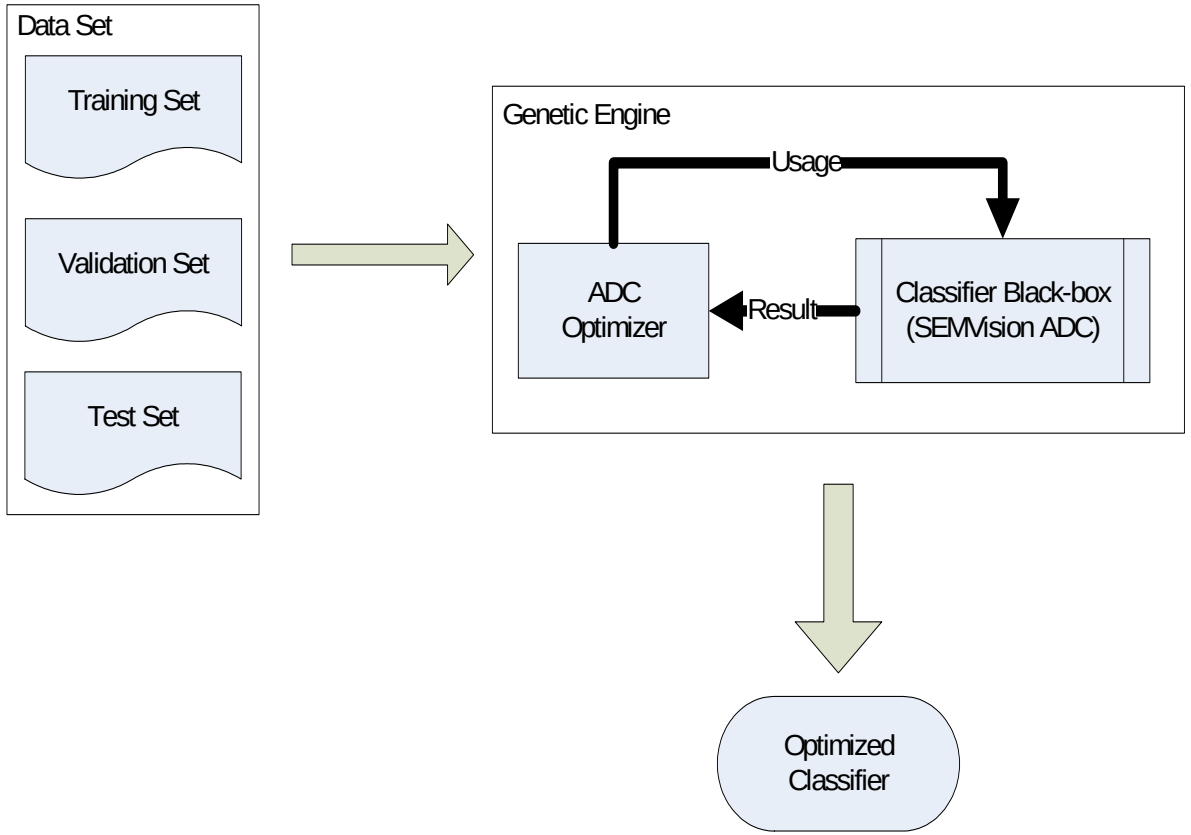
87.0% accuracy with 498 prototypical samples

We developed two GAs:

Basic & Enhanced

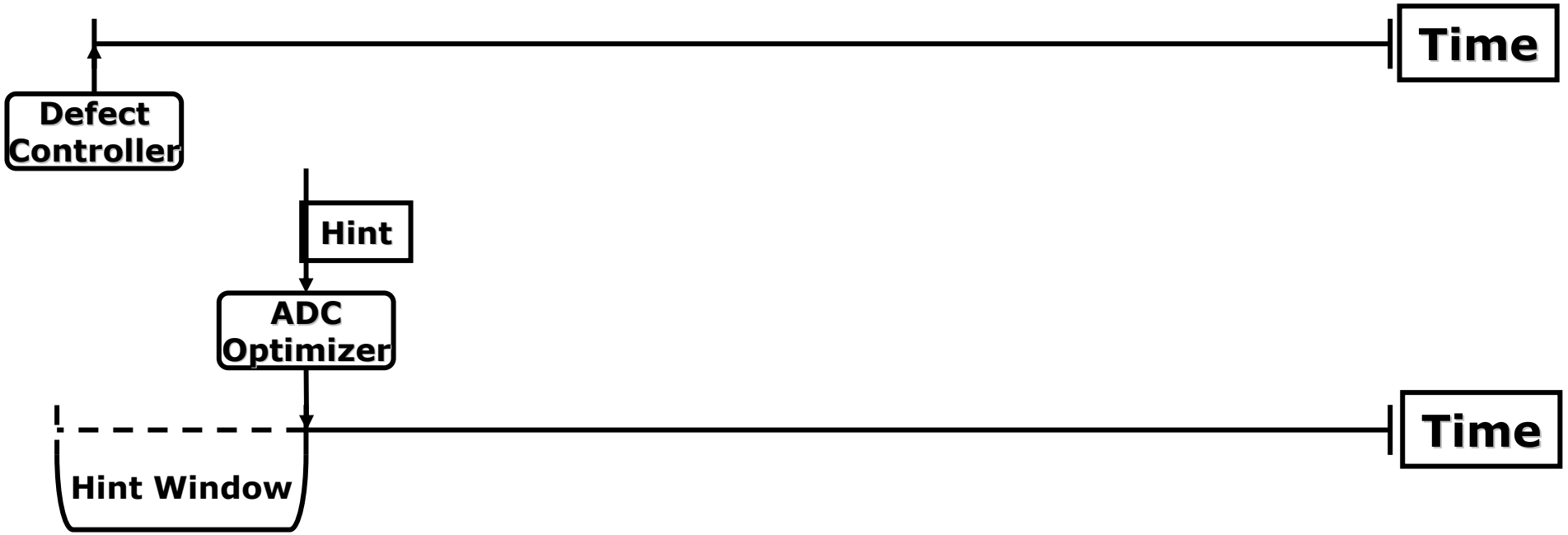
Basic GA

- Single GA, replacing limited human capability
- Automatically select optimal prototypical samples



Enhanced GA

- Anytime algorithm, remove human from loop
- Two GAs working in tandem, with a time delay between them



Enhanced GA (cont'd)

- Far better than human:

  90.1% accuracy with 213 prototypical samples

  (cf. human: 87%, 498)
- Faster convergence (than basic GA or human)
- Anytime optimization
- High accuracy
- Low complexity
- Automated process
- Ability to identify obsolete and relevant samples

Result is Human Competitive

(A) Patented / Patentable

(D) Publishable as new scientific result

(E) Equal/better than human-created solution to long-standing problem

(F) Equal/better than previously considered achievement

(G) Solves problem of indisputable difficulty

Why is Result Best?

- Automatic Defect Classification (ADC) is a well-developed technology, using heavily patented technology (criterion A)
- Goal simple to state, though arduous to attain: given a wafer image, classify the defects (criterion G)
- Problem compounded by poor data + deceptive environment in fab (problem changes constantly)
- Changing environment (new and obsolescent defect types) requires constant human intervention, limiting technology's effectiveness

Why is Result Best? (cont'd)

- Real "real-world" problem (work carried out in large, multinational company to improve multimillion $ product)
- Our evolutionary tool replaces manual bottleneck and limited human-optimization capabilities
- Major breakthrough: Our *GA* able to autonomously adapt to changing environment in fab
- Direct competition with humans (previous system)
- Silicon not only for semiconductors, also for solar energy

Why is Result Best? (cont'd)

- Our GA better in many respects than humans (criteria D, E, F):
  - Significantly higher classification rate
  - Increased throughput
  - Better generalization
  - Reduced complexity
- By replacing human bottleneck, we meet the industry's growing demand for robustness and stability in the production process
- No extant automated process equivalent to our model in any other product in the industry, worldwide

Why is Result Best? (cont'd)

In a nutshell:

1. **Real-world problem**
2. **Beats current leading product**
3. **Much better than previous human-based product**
4. **Can replace humans**
5. **Novel GA algorithm to boot…**