Basic Algorithms of Automatic Defect Classification System for Inspection Tools in Semiconductor Industry

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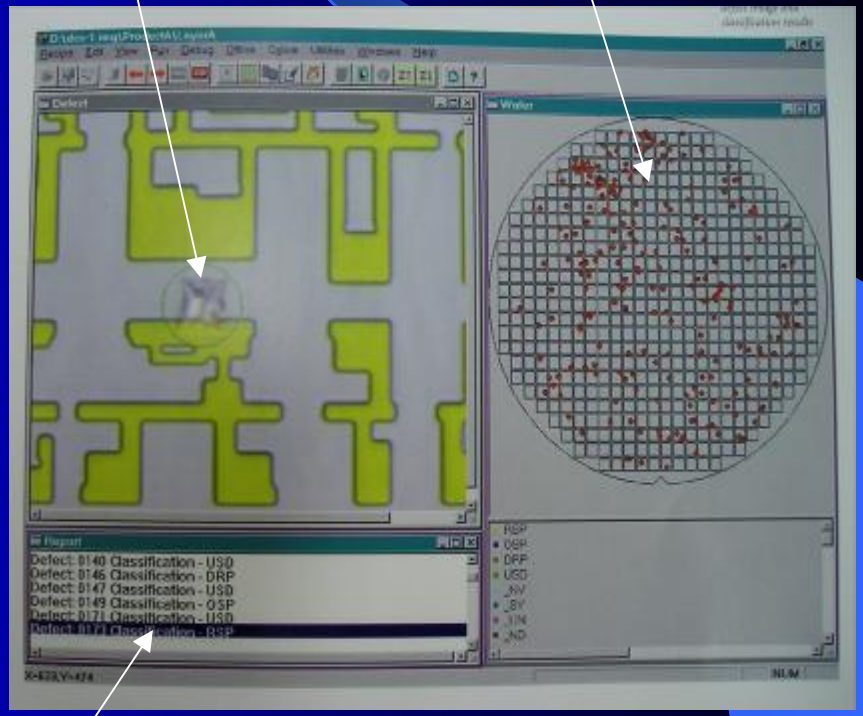
Wafer Inspection System
Axiospect 200

Defect Image obtained
by the Microscope

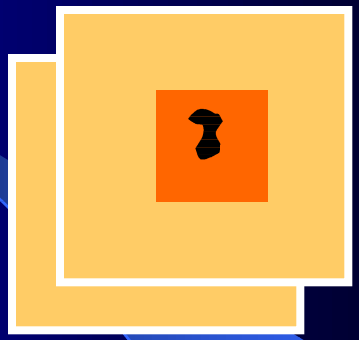
Defect Wafer
Map



Defect Classification Results obtained by ADC System

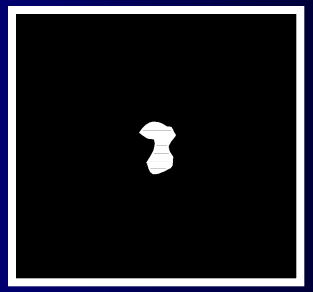
Defect Detection Phases

Alignment of Defect and Reference Images



Construction of

Defect Localization Mask



Defect Detection Types

- **Single Image Detection**:

Reference Image is Absent for a Set of Defect Images

- Dual Image **Detection**:

One Reference Image for Every Defect Image

One Reference Image for a Set of Defect Images

- **Three-Image Detection**:

Low Resolution Reference Image for

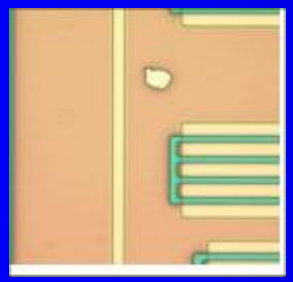
Low and High Resolution Defect Images

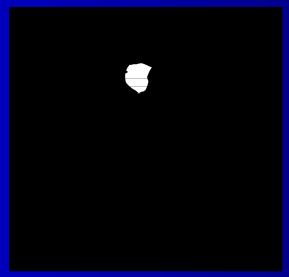
Image Processing and Computer Vision Tasks

- Image Enhancement (Filtration, Smoothing, Sharpening)
- Image Restoration (Zooming, Rotation)
- Image Registration (Alignment)
- Image Segmentation
- Image Binarization
- Morphology Analysis

Feature Calculation Process

- Morphological Features (Defect size and shape)
- Defect Localization Features





- Color and material Features
- Texture Features

Two Main ADC Tasks:

Defect Classification

Pattern Recognition Methods

(based on a learning set)

Support of the user for definition of new defect classes

Cluster Analysis Methods and Semantic Support Methods

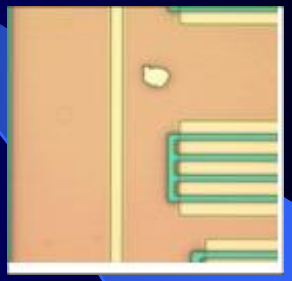
Defect Classification

Learning Set (images with class labels)

A priori information

Manual rules Correction

Current Image



Automatic Feature Selection

Automatic Rule Generation

Decision Rules

Classifier

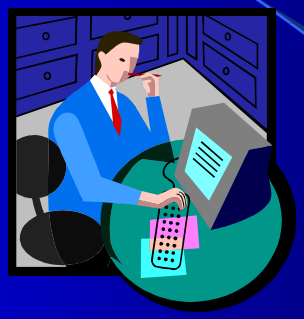
Defect Class Name

“Multi-Classification” Conception

Input Learning Information

Only a-priori, non-formalized info	Small statistical learning set with a-priori non-formalized info	Large statistical learning set
Fuzzy logic algorithm	Optimized fuzzy logic algorithm	0ptimized Nearest Neighbor algorithm

System for interactive support of the user for definition of new defect classes



Manual Feature Selection with Semantic Support

Automatic Generation of Class Verbal Descriptions

Semantic Support

Fuzzy Clustering Algorithm

Resulted clusters (new classes)

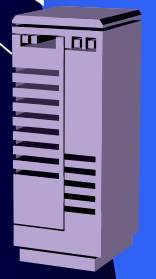
Statistical Information (Images without class labels)

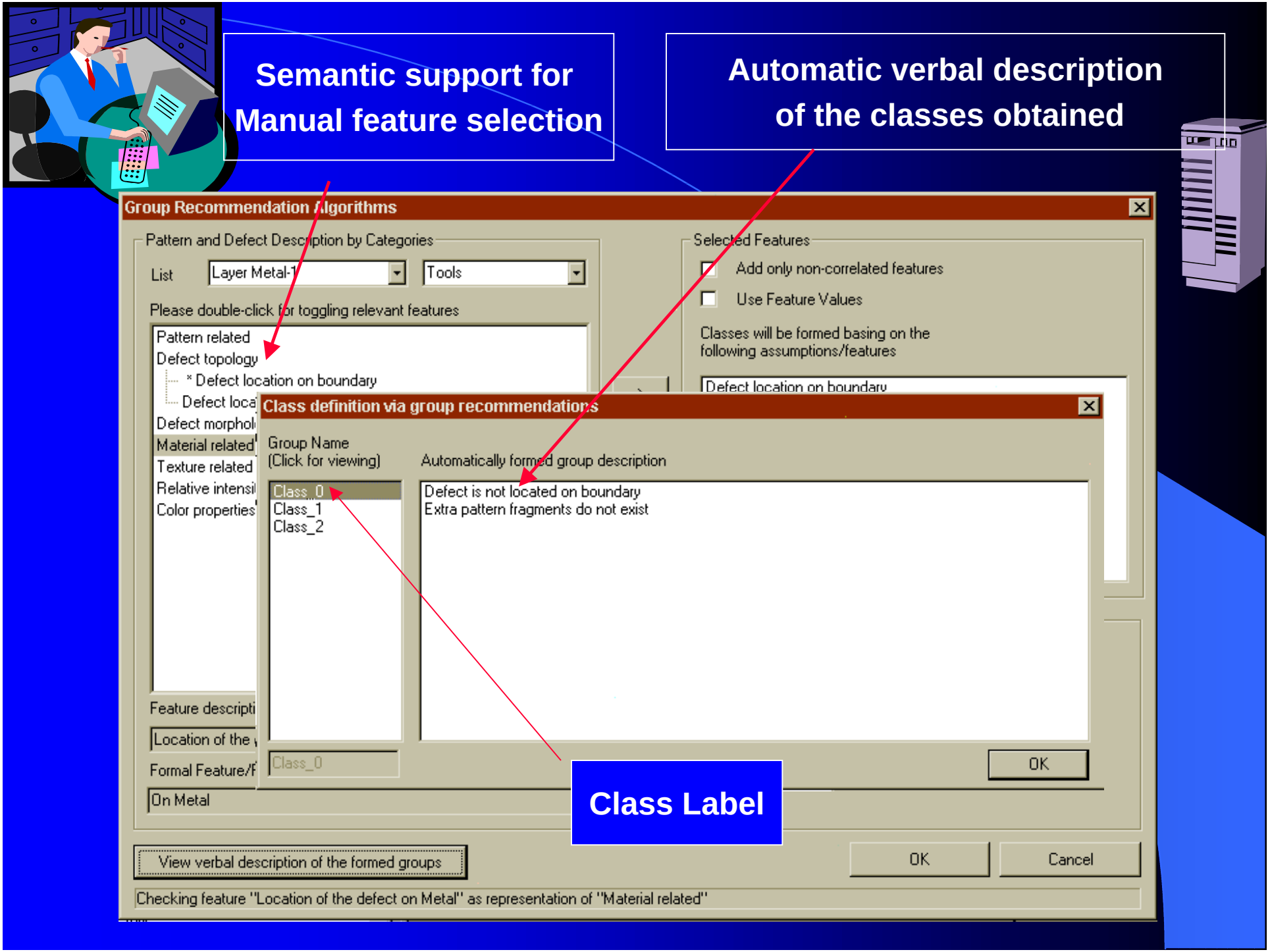
Semantic support for definition of new defect classes: Semiautomatic clustering

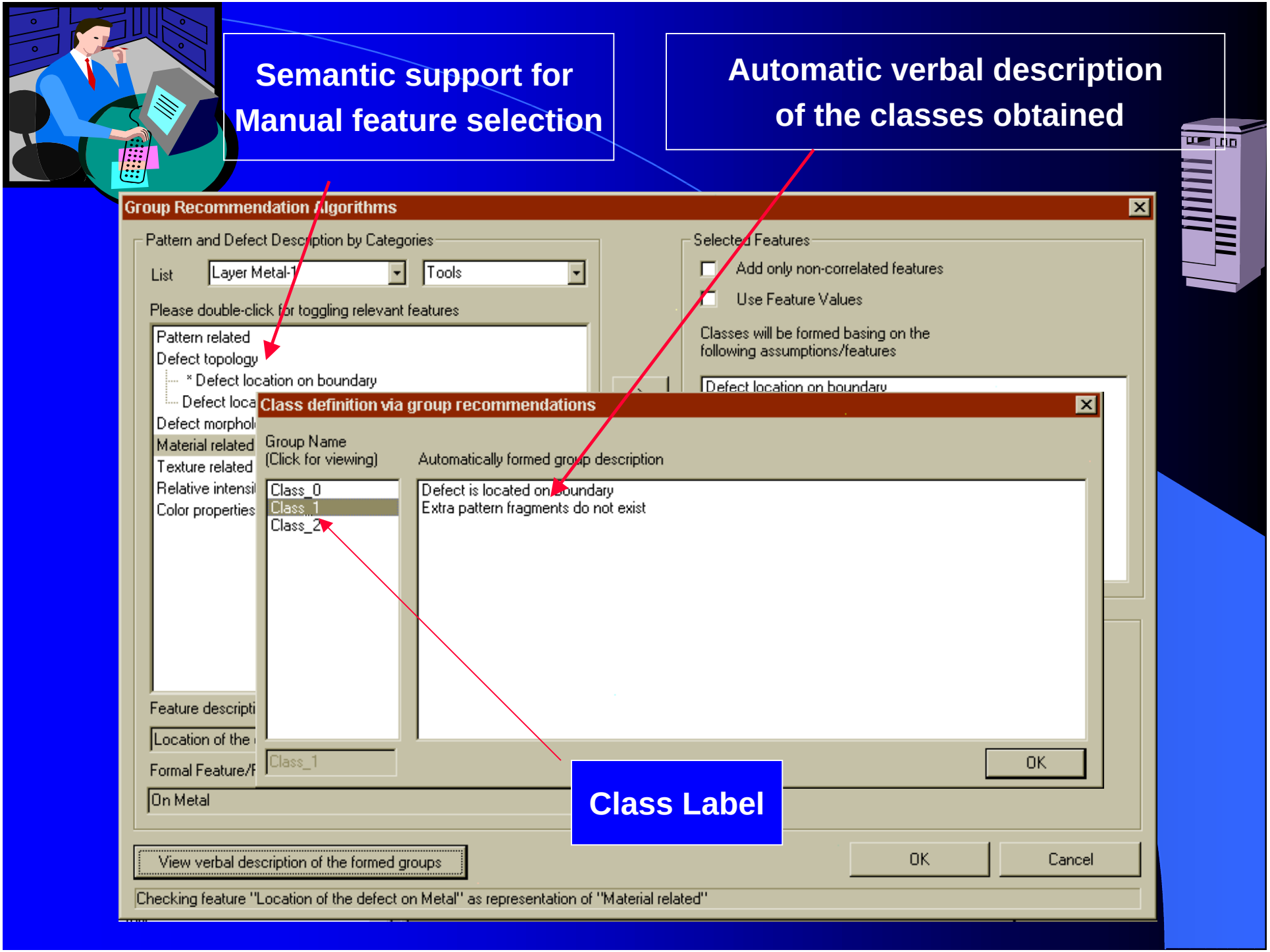
Navigation Support for manual feature selection

Automatic verbal description of classes obtained

Labeling the classes basing on their verbal description




Semantic support for
Manual feature selection
Automatic verbal description
of the classes obtained
Group Recommendation Algorithms
Pattern and Defect Description by Categories
List
Layer Metal-1
Tools
Please double-click for toggling relevant features
Pattern related
Defect topology
* Defect location on boundary
Defect loca
Defect morphol
Material related
Texture related
Relative intensi
Color properties
Feature descripti
Location of the
Formal Feature/F
On Metal
Selected Features
Add only non-correlated features
Use Feature Values
Classes will be formed basing on the
following assumptions/features
Defect location on boundary
Class definition via group recommendations
Group Name
(Click for viewing)
Automatically formed group description
Class_0
Class_1
Class_2
Defect is not located on boundary
Extra pattern fragments do not exist
Class_0
OK
Class Label
View verbal description of the formed groups
OK
Cancel
Checking feature "Location of the defect on Metal" as representation of "Material related"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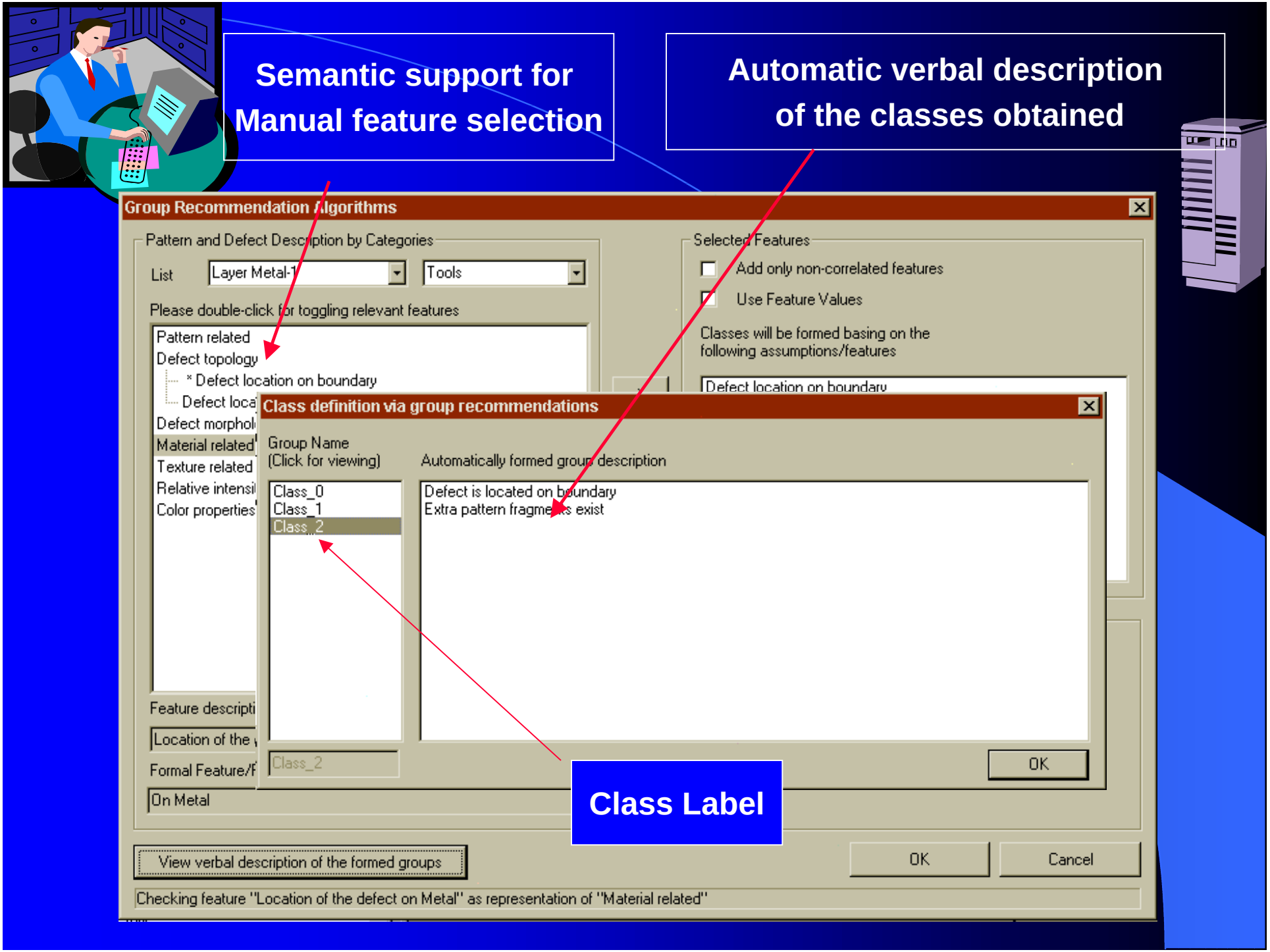
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Automatically formed group description
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Class_1
Class_2
Defect is located on boundary
Extra pattern fragments exist
Class_2
OK
Class Label
View verbal description of the formed groups
OK
Cancel
Checking feature "Location of the defect on Metal" as representation of "Material related"