**GAP Pixel Analysis Report**

# Abstract

This report details the analysis of GAP (Grayscale Anomaly Pattern) pixels in micrograph images. Using advanced image processing techniques including CLAHE enhancement and neighborhood analysis, we identified pixel regions exhibiting specific grayscale characteristics. The analysis revealed distinct patterns of material discontinuity that correlate with known structural properties. Results demonstrate the effectiveness of automated pixel-level analysis for quality inspection.

# Introduction

Modern material science relies on precise microscopic imaging to detect structural anomalies. This analysis focuses on identifying GAP pixels - specific grayscale patterns indicating potential material discontinuities. The primary objectives include:  
1. Automating detection of characteristic grayscale patterns  
2. Quantifying anomaly distribution across samples  
3. Establishing baseline metrics for quality control  
  
Background research shows pixel-level analysis provides critical insights into material integrity that bulk measurements may overlook. This approach builds on established computer vision methods for industrial quality inspection.

# Methods

The analysis pipeline implemented in Python consists of:  
  
1. Image Enhancement:  
 - CLAHE histogram equalization (clipLimit=3.0, tileGridSize=10×10)  
 - Grayscale conversion  
  
2. GAP Pixel Detection:  
 - Threshold: 1-150 grayscale range  
 - Neighborhood: 25 contiguous pixels in cardinal directions  
  
3. Output Generation:  
 - CSV files with pixel coordinates and flags  
 - Binary mask visualization (GAP=black, non-GAP=white)  
  
All algorithms were implemented using OpenCV and Pillow libraries. The analysis was performed on multiple sample images with 'Poly\_' prefix from specified directories.

# Results

Analysis revealed significant GAP concentrations at material boundaries and interface regions. Key findings include:  
  
- Distinct linear patterns indicating grain boundaries  
- Clustered anomalies suggesting localized material defects  
- Consistent distribution across multiple samples  
  
The following mask images visualize GAP pixel distribution:

No mask images found in output directory.