Automatic Defect Segmentation by Unsupervised Anomaly Learning

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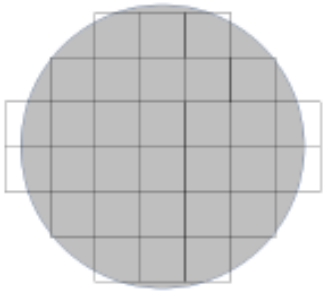
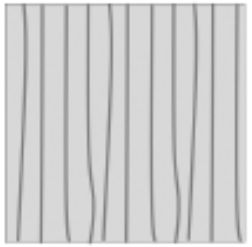
Goal: Segment real defects in SEM images by CNN training with no manual labeling.

Silicon Wafer

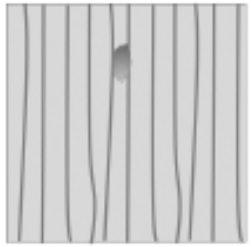


Scanning Electron Microscopy

Clean Background

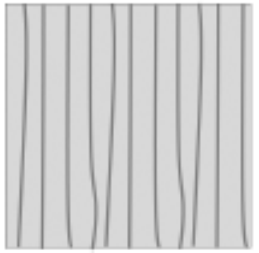


True Defect

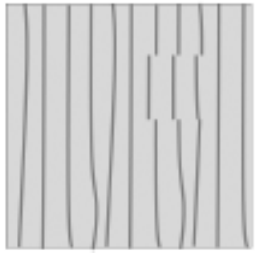


Copy-Paste Augmentation

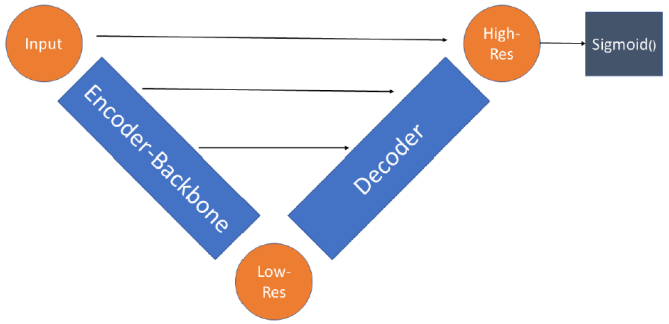
Clean Background



Simulated Defect



Architecture



Supervised Loss

$$WBCE(p,y) = \frac{1}{N}\sum_{i=1}^{N} w_i y_i \log p_i$$

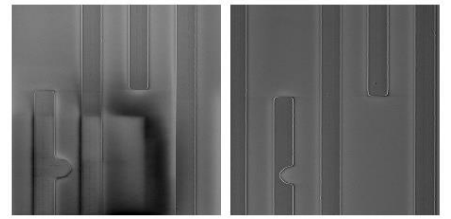
Contrastive Loss

$$CLR(x,A) = -\frac{1}{N}\sum_{i=1}^{N} \log \frac{\exp(sim(x_i, A(x_i))/\tau)}{\sum_j \exp(sim(x_i, A(x_j))/\tau)}$$

Consistency Loss

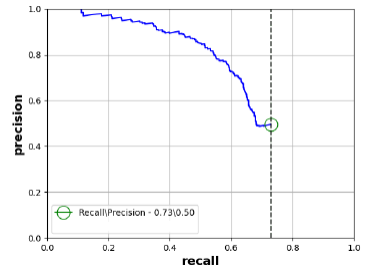
$$CL(p_1,p_2) = \sum_x p_1(x)\log(p_2(x)) + \sum_x p_2(x)\log(p_1(x))$$

Simulation SEM Images



Unsupervised Performance

Unsupervised Algorithm	F-Measure	Precision	Recall
D-CLR	**0.65**	0.65	0.64
W-BCE	0.62	0.7	0.55



Fully Supervised Performance

Algorithm	F-Measure	Precision	Recall
Teacher-Student-Ref	**0.87**	0.83	0.92
D-CLR-Ref	0.86	0.82	0.89
W-BCE-Ref	0.85	0.84	0.86
Teacher-Student	**0.8**	0.75	0.85
D-CLR	0.74	0.69	0.78
W-BCE	0.82	0.76	0.87
Classic-Ref	0.73	0.59	0.92