

Technical Report: Ferritic Steel Microstructure Synthesis with GAN Models

Model	Architecture	Key Features/Regularization	Training Details	Best FID	Best SSIM	Notes
Baseline DCGAN	Standard DCGAN (Generator, Discriminator)	Standard Conv blocks, Gradient Penalty, No attention	256x256, 64 batch, BCELoss, Adam, LR Schedulers	1448.85	0.0786	Basic GAN, slow FID improvement
Enhanced GAN	DCGAN + Spectral Norm + Self-Attention	Spectral Norm, Self-Attention, Grain Size Penalty, ColorJitter	128x128, 16 batch, BCEWithLogitsLoss, Adam	145.83	0.0506	Significantly improved FID, robust features
WGAN-GP	WGAN-GP + Multi-Scale Discriminator + Self-Attention	Gradient Penalty, Spectral Norm, Self-Attention, Edge Loss	128x128, 8 batch, Wasserstein loss, Adam	177.95	0.0599	Stable convergence, improved quality

Summary Points

- **Baseline DCGAN:** Simple but lays the foundation, shows slow progress and low quality compared to advanced models.
- **Enhanced GAN:** Adds robust regularization and attention, leads to marked improvement in both metrics and fidelity.
- **WGAN-GP:** State-of-the-art stabilization and regularization, ideal for further research and production; slightly behind Enhanced-GAN's best FID but stronger SSIM and stability.