

Shot Noise: the importance of considering 2 dimensions

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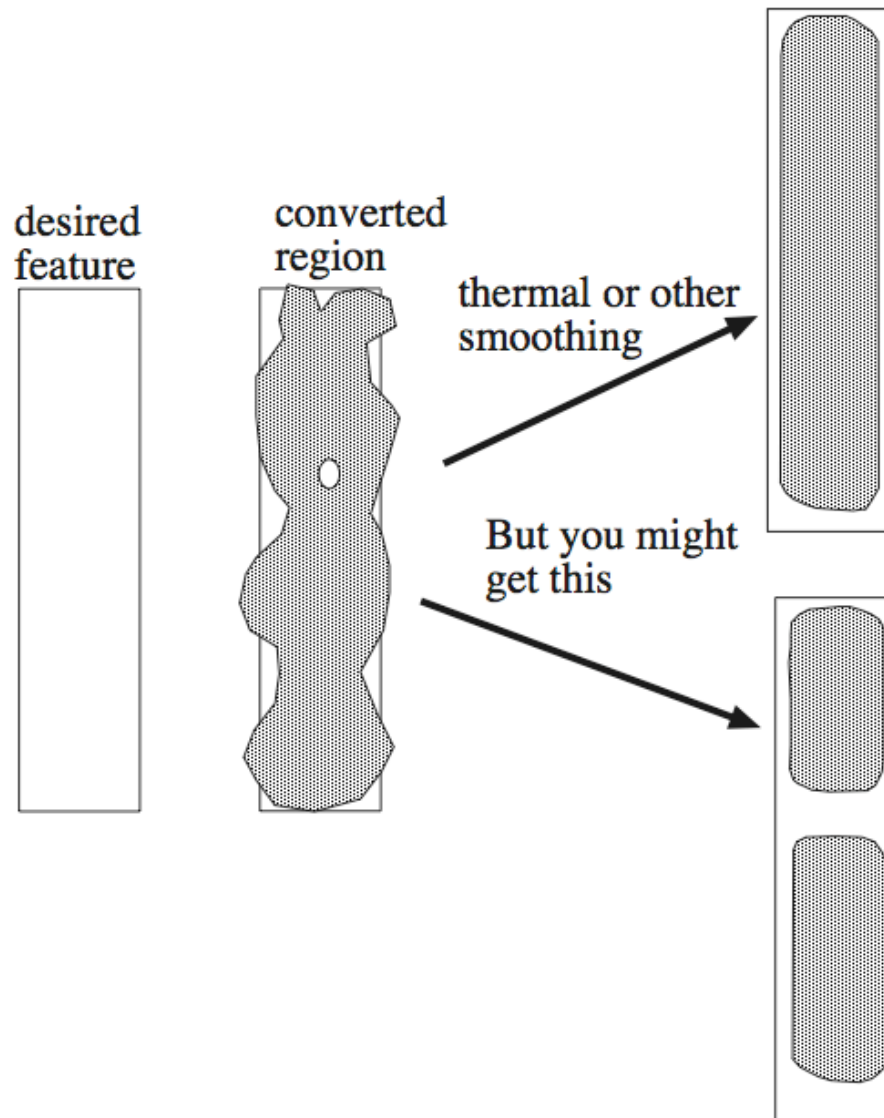
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Line-edge smoothing



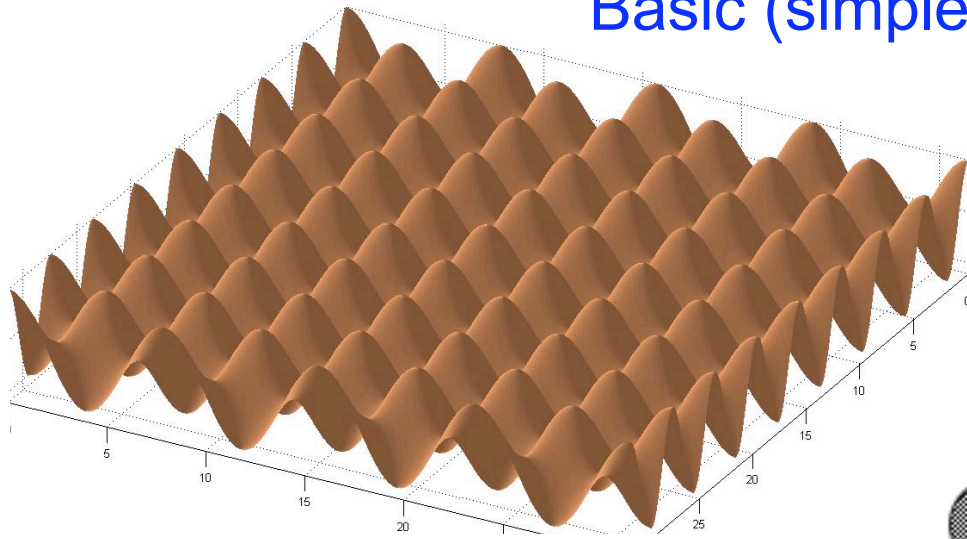
Rough line edges can be smoothed thermally or via acid-diffusion phenomenon.

Don't be fooled!!

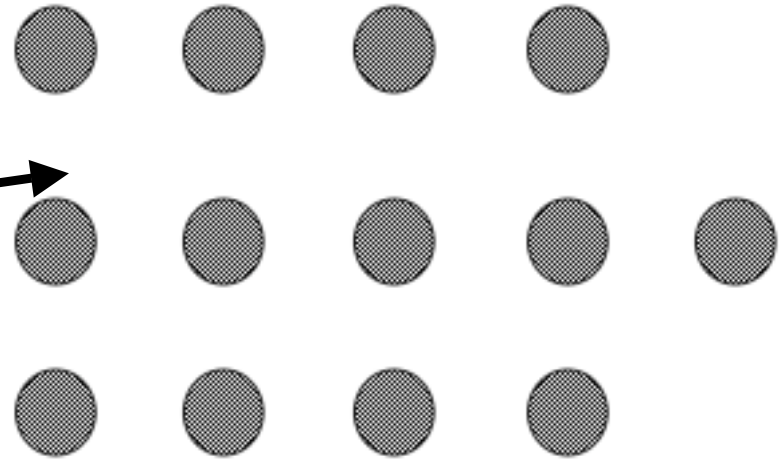
Shot noise is a fundamental limitation on information content and fidelity

Shot-noise analysis should consider 2D patterns, not just gratings

Basic (simplest) 2D intensity distribution



Holes or posts



Will resulting pattern be free of errors due to shot noise?



Min pitch → | ←

Chem. Amplified resists => 3D domain of conversion



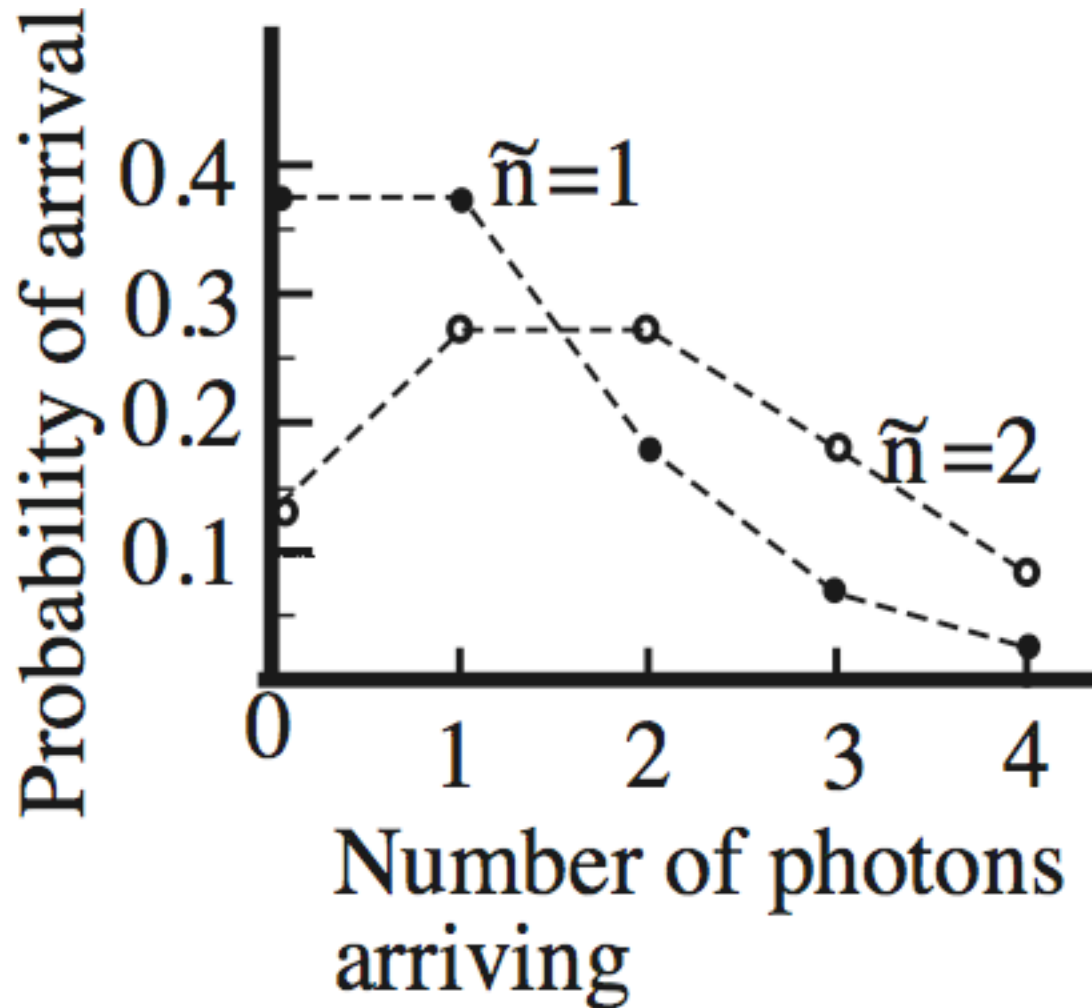
Not really a sphere

But photons arrive randomly => Poisson statistics



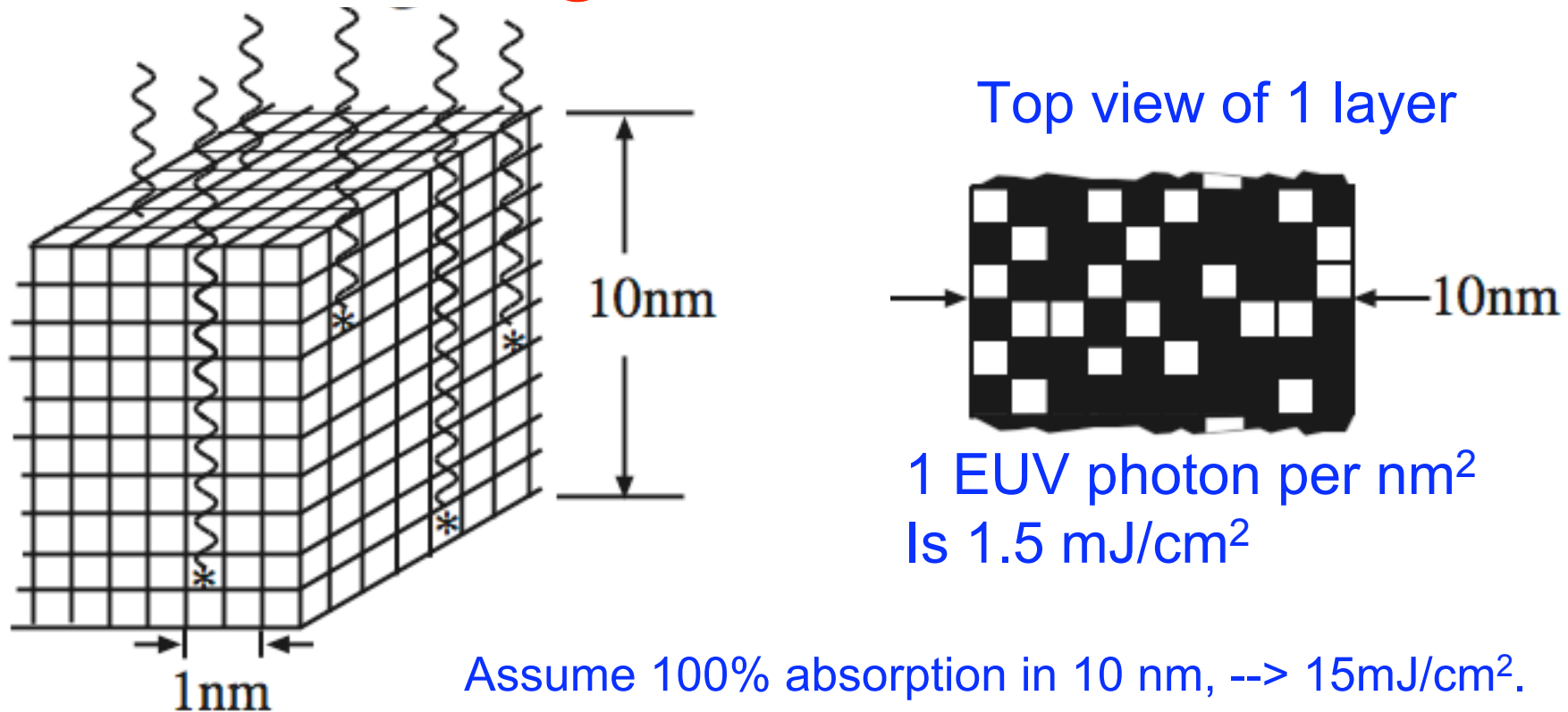
Domain diam. ~ 1 nm (G. Wilson)

Poisson Statistics for arrival of photons



Note that if $\tilde{n} = 1$, the probability that none arrive is 37%

Modeling shot noise effects



Assume 100% absorption in 10 nm, --> 15 mJ/cm^2 .

If 50% absorption in 10 nm, --> 30 mJ/cm^2

If 50% quantum efficiency --> 60 mJ/cm^2

If 2 nm pixels, divide by 4, e.g., 15 mJ/cm^2

Conclusion

- Must consider 2D patterns, not just lines.
Otherwise, self deception (expensive).
- Shot noise is a fundamental limit to information content of pattern
- For 1 nm line-edge roughness, 5 mJ/cm² is highly doubtful.